Masaryk University

Faculty of Economics and Administration

Study program: Public Economy and Administration

ENVIRONMENTAL KUZNETZ CURVE - THE CASE STUDIES FOR THE CZECH REPUBLIC AND FINLAND

Environmentální Kuznetzova křivka – Případová studie pro Českou republiku a Finsko

Master thesis

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Cíl práce, postup a použité metody:

Thesis objectives:
In recent years an increased attention oriented towards the problematic aspects of the environment has been recorded. Environmental Kuznets Curve theory, dealing with deteriorating environmental quality and its dependence on the growth of income per capita and defined through and inverted U curve, is associated with this area. Due to different levels of environmental pollution by individual pollutants, we encounter various breakpoints, reflecting the level of wealth per capita and the degree of environmental pollution.

The main objective of this thesis will be prove or disprove the theory of Environmental Kuznets Curve for individual selected pollutants (CO2, etc.) through mathematical and statistical methods and data of the Czech Republic and Finland. Depending on the different levels of environmental pollution in the Czech Republic and Finland case studies will be compared. One of the partial objectives will be evaluation of factors (internal and external) that could influence the waveform of Kuznetzovy curve.

Methodology:
1. Defining the subject and the problematic aspects influencing the theoretical assumptions of the selected issue.
2. Analysis of the current state and theoretical background - literature review.
3. Data collection for the case studies of the Czech Republic and Finland.
4. Analysis, evaluation and synthesis of data.
5. Comparation of case studies results.
6. Evaluation and discussion of the results, disproving or confirmation of the theory in the context of possible external influences, summary and recommendations.

In the thesis will be used methods of analysis and comparison of data, statistical methods, regression analysis and synthesis of information.

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Literatura:

ČAMROVÁ, Lenka, Eliška VEJCHODSKÁ a Jan SLAVÍK. *Ekonomie životního prostředí : teorie a politika*. 1 vyd. Praha: Alfa nakladatelství, 2012. 287 s. ISBN 9788087197455.

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Anotace

Diplomová práce se věnuje problematice Environmetální Kuznetsovi křivky (EKC), s cílem potvrdit či vyvrátit její platnost pro CO_2 a SO_2 polutanty v České republice a ve Finsku. Při empirické analýze byla věnována pozornost externím efektům, především environmentálním regulacím, které mohou ovlivnit proměnné a tvar EKC. Na základě výsledků regresní analýzy byla potvrzena existence křivky obráceného tvaru písmene U (EKC) pouze pro finské emise CO_2. Tento závěr potvrzuje tvrzení EKC hypotézy, která říká, že s rostoucím bohatstvím země, klesá výskyt množství daného polutantu v rámci životního prostředí dané země. Naopak emise SO_2 nepotvrdily existenci křivky ve tvaru obráceného písmene U, ale křivky ve tvaru písmene U v obou zemích. V tomto případě není možné existenci EKC potvrdit ani vyvrátit, a to především díky nedostatečné dostupnosti dat.

Annotation

This diploma thesis deals with the Environmental Kuznets curve in order to prove or disprove its validity for CO2 and SO2 pollutants in the Czech Republic and Finland. During empirical

analysis the attention was also paid to external effects, especially to environmental regulations, which may influence the variables and EKC's shape. Based on the results of the regression analysis, the existence of a U-shape curve (EKC) was confirmed only for Finnish CO2 emissions. This conclusion confirms the ECC hypothesis assertion that the country's rising wealth reduces the amount of pollutant in the country's environment. Conversely, SO2 emissions did not confirm the U-shaped curve, but the U-shaped curves in both countries. In this case, the existence of the EKC cannot be confirmed or refuted, due to insufficient data availability.

Klíčová slova

Finsko, Česká republika, Environmentální Kuznětzova křivka, vztah mezi HDP na hlavu a znečištěním na hlavu, regresní analýza, environmentální regulace, Pollution Heaven Hypothesis

Keywords

Finland, The Czech Republic, Environmental Kuznets curve, relationship between GDP per capita and pollutants per capita, regression analysis, environmental regulations, Pollution Heaven Hypothesis

Declaration

I hereby declare that I have developed and written this thesis independently, using only the sources listed, in accordance with Czech legal regulations and the internal regulations of the Masaryk University and the Faculty of Economics and Administration.

In Brno, January 2018

Author's signature

Acknowledgements

I would like to express my gratitude to doc. Ing. Mgr. Jana Soukopová, Ph.D. and Professor Hannu Laurila, my thesis supervisors, for professional guidance and useful critiques of my thesis and to Ing. Robert Jahoda, PhD. and Ms. Terhi Nieminen for providing me with the opportunity to study a double degree master program at the University of Tampere and their support during my studies. Furthermore, I would like to thank my family for support during my studies.

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INTRODUCTION

The interactions between society and companies are perceived to be a part of the economy. The economy is taking a place within the environment system. Therefore, the interactions or economy are perceived to be a subsystem of the environment. Moreover, the economy uses natural resources as major inputs. Hence, a wide range of environmental pollution may be observed as a byproduct of human activities. Accordingly, if activities take a place within the environment the pollution is transmitted into environment system and it is returned back to the human subsystem.

Due to the worsening quality of the environment and increasing availability of environmental data in the last decade of the 20th century, public discussions and proposed solutions have been more frequent. Since the air quality is perceived as a global issue, it is necessary to treat the problem and cooperate on its improvement across national borders. Thus, a need to find an efficient tool for explanation, how different external effects influence an environmental degradation, have been more actual. The air, as a component of the environment, may be said to be noncompetitive and nobody can be excluded from consumption. Therefore, the air is considered as a public good.

Moreover, along with environmental changes in the mid-20th century, the discussions about maintaining the environment for future generations emerged. Owing to excessive costs of maintaining the quality of the environment and avoiding the future degradation, the future generation as well as world of nature will have to pay off excessive costs. Therefore, to pass on the next, not less, amount of the environment than it actually used, should be the task of each generation. Thus, the challenge of current generation should be to compensate future generations for environmental damages. In this case is talked about the phenomenon of intergenerational externalities. In this matter, the state or government should play a key role as the main body correcting these remedies through environmental regulatory instruments. (Šauer, 1996)

One hypothesis dealing with income-environmental relationship is called the Environmental Kuznets curve (EKC). It posits that there is a relationship between various environmental pollutants and the per capita income. The paper *Economic growth and the Environment* explains EKC hypothesis as follow: *"Pollution appears to rise with GDP at low levels of income, but eventually to reach a peak, and then to fall with GDP at higher levels of income. Therefore, the relationship between environmental degradation and income is represented as an inverted U-shape of the Environmental Kuznets Curve."* (Grossman & Krueger, 1995) Moreover, in response to economic growth a variety of effects are associated with the curve. These effects influence not only the amount of environmental pollution and the ratio of economic development of the country but also EKC model curvature.

The main objective of my Master's Thesis will be to prove or disprove the theory of Environmental Kuznets Curve for individually selected pollutants (CO2, etc.) through mathematical and statistical methods, and data of the Czech Republic and Finland. Depending on the different levels of environmental pollution in the Czech Republic and Finland case studies will be compared. One of the partial objectives will be an evaluation of factors (internal and external) that could influence the waveform of Kuznets curve.

The first section will introduce existing research on particular polluters and areas related to this thesis as well as other external variables or effects that have been examined as factors influencing the environmental-income relationship. It is also known that increasing income also increase people's standard of living, that is, as people increase their state of well-being, they become more interested in reducing environmental pollution and they begin to create more pressure for environmental policy and regulations. For example, *"carbon dioxide emissions are directly related to use of energy, which is an essential factor in the world economy, both for production and consumption. Hence, the environmental-income relationship has important implications for environmental and economic policies."* (Azomahou et al.,2006, p. 1349) Therefore, in the second part will be discussed important national and international environmental regulations as another determinant of EKC model.

In conclusion, to achieve the main thesis' objective, a regression analysis will be used in the third part. The analysis will be done on CO2 and SO2 pollutants in the Czech Republic and Finland. Finally, the model's finds will be discussed and confronted with theoretical observations and model limitations that could have an impact on its results.

1 ENVIRONMENTAL KUZNETS CURVE

The main aim of this chapter is to introduce the Environmental Kuznets curve hypothesis. Firstly, I will focus on the theoretical framework and relationship between EKC's variables. Owing to external factors that may appear as a certain response to economic growth I will continue with description of these phenomena and their impact on economic growth, the environment as well as on curvature of the EKC model. Finally, I will analyze recent EKC study findings dealing with CO2 and SO2 pollutants, whether they have proved or disproved EKC hypothesis and which external factors have been involved in these studies.

1.1 Theoretical framework of the Environmental Kuznets Curve

The Environmental Kuznets Curve describes the relationship between environmental pollution and economic growth as an inverted-U shape. It was first put forth and published in the study *Economic Growth and Income Inequality* by Simon Kuznets in 1955. For the purpose of Kuznets's study were used data from the USA, Great Britain, and Germany. Kuznets wanted to prove if the income society inequality and breakdowns between social groups increase with increasing economy at first and then, after reaching a turning point, star declining again. His statement is that relative income distribution tends to equality. He has mentioned two main factors causing a rise of income distribution inequality. The first effect is the concentration of savings in higher income groups and the second effect in process of industrialization and urbanization. The income distribution in urban society is less egalitarian than in rural society. Thus, the transition from a traditional economy and agriculture to a modern industrialized economy should lead to a rise in income inequality according to Kuznets's model. Otherwise, Kuznets is very critical of his work and alerts readers that the study is 95% mere speculation. (Kuznets, 1955)

Later, in early 1990s, when data of various environmental pollutants became available, owing to international organizations and increasing interest in environment, the idea of empirical testing the inverted U-shape for the relationship between economic growth and environment has begun to appear.

Most studies claim that causality between economic growth and environment (EKC) may be explained as developing process of poor economies. (Arrow, 1995, p. 520) In spite of, limited impacts of subsistence economic activities on the resource base, the quality and intensity of environmental degradation at low income levels is limited. With accelerating economic development, due to growth of agriculture and other resources extraction as well as the take-off of industrialization, the rate of resource depletion starts to exceed the race of resource regeneration, and the waste generation increases in quantity and toxicity. As soon as economy growth reaches higher level of development, the structural change occurs towards information-intensive industries and services coupled with increased environmental awareness, enforcement of environmental regulation, better technology and higher environmental expenditures that result in levelling off and gradual decline of environmental degradation. (Panayotou, 1993, p. 1)

1.1.1 EKC model

The main aim of following part is to describe the EKC diagram and how the model projects the income-environmental degradation relationship. The EKC diagram shows the level of pollution on the vertical axis and then the level of per capita income is in on the horizontal axis (see Figure 1). The relationship is said to be a unidirectional causality. Thus, income causing environmental changes not vice versa. (Coondoo and Dinda, 2002)

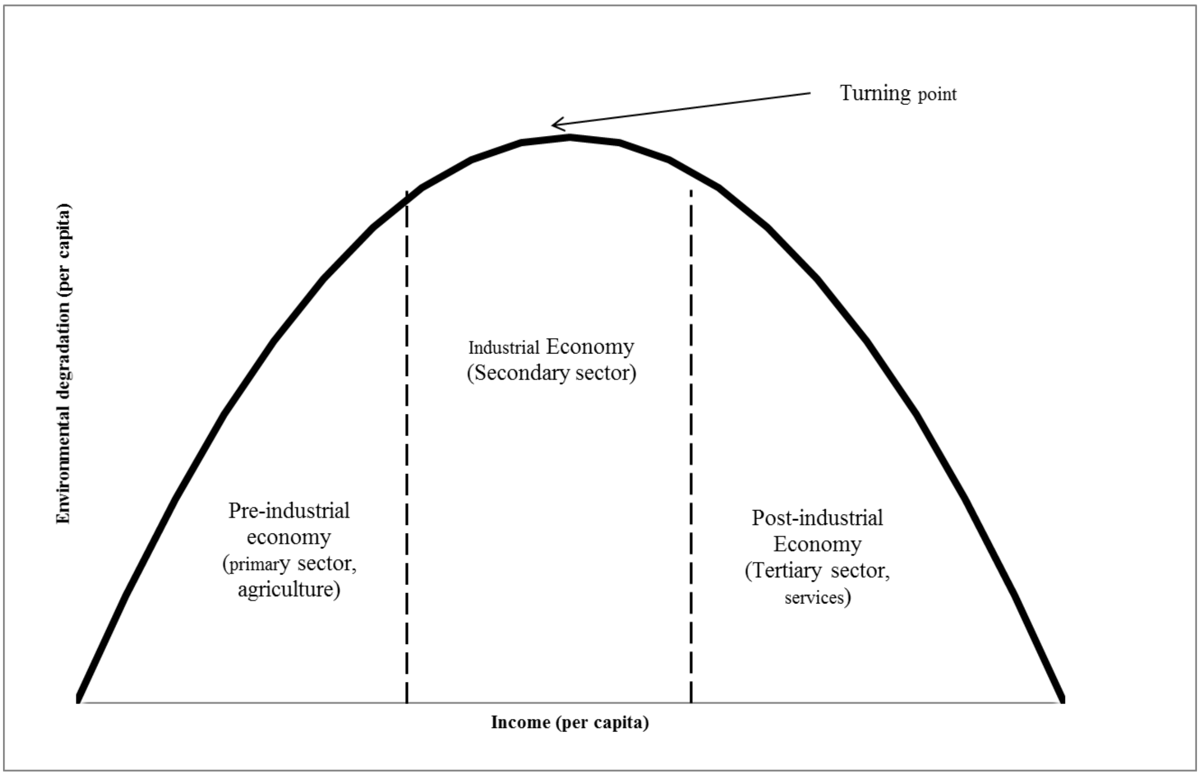
The early stage of economic growth the EKC mode calls as *pre-industrial economy* (see Figure 1). Countries are in process of development; therefore, agriculture and primary sector have the dominant position in the economy. The government's concern is mainly focused on economy growth; thus, negligence or low environmental problems awareness may be observed. However, the environmental pollution grows more rapidly. Nevertheless, for example, Arrow

(1995, p. 520) perceives increased amount of pollution as *"an acceptable side effect of economy growth"* in the early stage of development where clean environment poses luxury good.

Later, when the economy is in the so-called *industry economy* stage. The economy growth is more significant, due to higher amount of industry situated in the country. The society's stage of well-being starts to be slightly satisfy and concentrates its interest on environmental issues. Moreover, due to sophisticated technologies, innovations, and technological progress of production are countries able to treat the environment less than before. Not only new technologies and processes but also press on the government causes a decrease of environmental degradation. In the industry stage the EKC model reaches the maximum or the turning point.

Afterward, continuing economy growth leads to the last stage where the environmental degradation starts decrease again. The post-industrial economy is characterized by tertiary sector – services. Along with increasing environmental value, environmental regulations are becoming effective and environmental institutions are more accepted by society. (Dasgupta et.al., 2002)

Figure 1: Environmental Kuznets curve (EKC)



Source: Kaika et al.,2013, p.1394; edited by author.

In conclusion, Dinda (2004, p. 431) summarizes the idea of the EKC model as follows: *"In general, the environmental pressure increases faster than income in the early stage of development and slows down relative to GDP growth in higher income levels."*

EKC (see Figure 1) can result if a few conditions are meet as income increase in a society (Dasgupta et al., 2002, p. 149)

1) The marginal utility of consumption is constant or falling
2) The disutility of pollution is rising
3) The marginal damage of pollution is rising
4) The marginal cost of abating pollution is rising

The curvature of the EKC model may be also explained by ***income elasticity*** of environmental quality. As society starts to achieve higher living standards (mainly in the last stage of economy development – see Figure 1), its interest starts to be more focused on environmental conditions in the area where they live. Ruttan (1971, p. 707-708) explains income elasticity relating to EKC model as follow: *"In relatively high-income economies the income elasticity of demand for commodities and services related to sustenance is low and declines as income continues to rise, while the income elasticity of demand for effective disposal of residuals and for environmental amenities is high and continues to rise. Unlike poor countries where the income elasticity of demand is high for food and low for the quality of the environment."* Accordingly, with increasing income increase also society willingness to pay greater amount of its income. The ***change of society behavior*** may be observed, for example, in financial support of environmental organizations or shift to less environmentally damaging products. (Rocca, 2003)

1.1.2 EKC and Economic Growth

The relationship between environmental degradation and economic growth is said to be controversial and speculative. On the one hand, the economy growth can increase the level of environmental degradation. If the country's development is associated with industry growth and growing amount of output that also supposes more amount of input, thus, increasing incidence of emissions and wastes may be expected. On the other hand, increasing economy and industry growth assume more efficient technologies that help to reduce emissions per unit of economic output. (Panayotou, 1993). Also, Grossman and Kruger (1995, p. 353) perceive the issue as Panayotou does, they said: *"We find no evidence that environmental quality deteriorates steadily with economic growth. Rather, for most indicators, economic growth brings an initial phase of deterioration followed by a subsequent phase of improvement."*

The study *The Ups and Downs of the Environmental Kuznets Curve* is talking about causality between GDP per capita and the level of environmental degradation that is explained through Robinson Crusoe model. The U-shape curve was explained in the example of driving risks accidents: *"Poor people either do not own cars, or do not drive them much. Rich people own* *cars and drive them, but own late-model, well-maintained vehicles with extra safety features. Middle-income people, who drive more miles in less-safe vehicles, suffer the highest risk."* (Levinson, 2000, p.19) Levinson wanted to prove that pollution does not necessarily increase with economic growth and the observed inverted U-shaped relationship is neither necessary nor sufficient for Pareto-efficient environmental policies. Which means that another economic growth of already developed countries do not need to lead to an increase in pollution at a certain stage of economic development, because of advanced technologies. However, from Pareto-efficient view, it may happen that developed countries shift heavy polluter production to developing countries. Thus, developing countries will suffer from the shift, because these countries neither be able to move heavy-polluter production to other counties nor they have developed technologies to be able to reduce these emissions (here we are talking about Pollution Heaven hypothesis). Thus, Levison stressed the need to look at EKC from a wider perspective and perceive effects that may accompany GDP growth.

1.1.3 EKC - External effects and Hypothesis

For the purpose of this thesis is also necessary to describe other effects that may respond to economic growth and influence the rate of environmental degradation thus it may be reflected in EKC curvature.

The first empirical study dealing with EKC issue was Environmental Impact of a North American Free Trade Agreement by G. Grossman and A. Kruger, issued in 1995. This document was prepared for purposes of the US-Mexico Free Trade Agreement conference, where environmental consequences caused by the reduction of trade barriers, owing to North American Free Trade Agreement (NAFTA), were discussed.

Initially, the agreement was criticized mostly by environmental organizations, owing to the possibility of deteriorating the environment in Mexico. In accordance with the cross-border shipment of environmentally damaging production from the USA and Canada, due to a more benevolent system of environmental regulations in Mexico, the higher level of environmental pollution, as well as depletion of scarce natural resources were expected. Secondly, the document has also mentioned possibility of undercutting regulatory standards in the USA. The USA will not want to lose their international competitiveness; therefore, the environmental standards may become less strict in order to higher demand of industry group for less stringent pollution regulations, thus, the possibility of a higher amount of environmental pollution was expected as well.

The analytical part of the study is focused on the production of sulphur dioxide, suspended particles and darker matter in a differ part of cities. For ensuring objective research outcomes, the data for research were monitored in 47 cities in 28 different developed as well as developing countries. It was found that higher pollution concentration is situated in city center, mostly in industrial areas, than in the residential area. Moreover, the research provides interesting finds about pollution in communist-ruled countries that suffer a significantly greater amount of pollution.

In conclusion, authors have mentioned potential benefits of liberalization for Mexico:

1) The access Mexico to U.S. market support growth of income in the country, increase political pressure in order to strengthen environmental protection as well as change private consumption behavior.
2) The support less environmentally polluting sectors. Mexico has its comparative advantage in an abundant representation of unskilled workers. Therefore, the country should be more focused on production that requires intensive use of physical and human capital. Consequently, the shift from capital-intensive to human-intensive activities becomes well side-benefit of specialization change relate to the reduction of environmental pollution.
3) On the other hand, if market liberalization caused a flow of highly skilled workers or capital from the U.S. to Mexico then the production change would occur, owing to comparative advantage change.

The study has mentioned three mechanisms that could affect the level of environment pollution, owing to change of trade barriers:

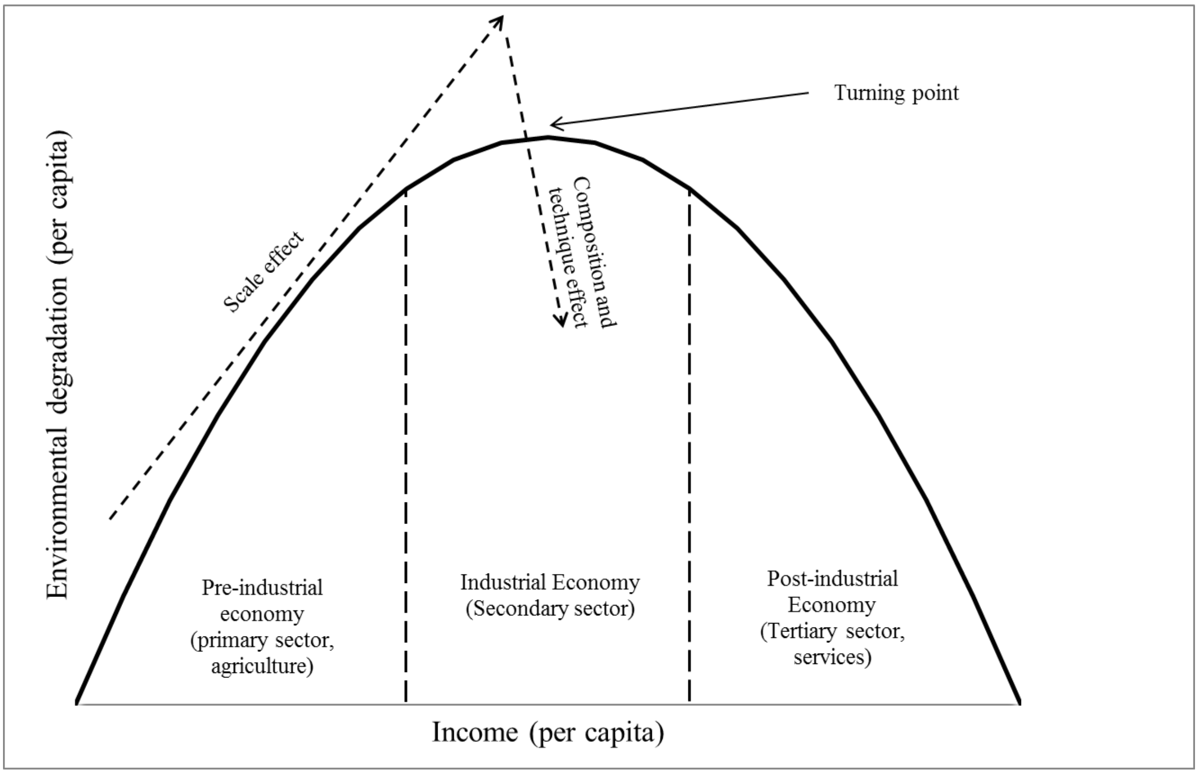
The Scale effect is an outcome of economic activity expansion. If the particular activities remain unchanged the higher investment liberalization causes an increase of total amount of pollution. As an example, fossil fuels combustion caused by the trucking industry may be mentioned. Due to increase trade expansion, the demand for cross-border transportation services increase, which nature remain unchanged, hence, contribute to the higher amount of pollution in the air.

The Composition effect that is connected to the comparative advantage of a particular country as a consequence of trade liberalization. If the competitive advantage derives from less stringent environmental regulation the shift out of production in industries that have relatively high abatement costs of production may be observed. As an outcome of above-mentioned example is a higher amount of pollution and environmental degradation. On the contrary, Dinda (2004, p.435) perceives this effect as positive one. Along with economic growth, the economy structure tends to also change too. Thus, shift from low intensive agriculture through the high-intensity industry to services and knowledge-based technology industry may be observed. Moreover, as the economy becomes richer, government expenditures start to be more focused on environment and invest into R&D in order to develop new and less polluting sophisticated technologies. Liobikiene (2015, p. 183) analyzed how increased expenditures on R&D in EU countries influence changes in Greenhouse gas (GHG) emissions. He found an indirect link between these variables, because a reduction of GHG emissions may be seen only when technologies, on which expenditures were used, are implemented in production etc.

Changes of process techniques caused by the trade barriers reduction. Liberalization causes increasing income and development of the country, thus, for production are used more sophisticated techniques which means that the same output is not produced by the same technique as before, but by cleaner and more efficient techniques. With economic growth, may be also observed higher demand for a cleaner environment, the pressure on environmental regulation become more significant. Especially in less developed countries may be assumed greater fall in pollution per unit than in already developed countries. On the other hand, however, countries could operate with the same industrial structure, the level of industrial emissions and wastes may be different, owing to different quality or vintage of production technologies. Panayotou (1993, p. 2)

To conclude, for explanations how above-mentioned effect behave in the EKC model serves the Figure 2. As may be seen the Scale effect press the amount of environmental degradation upward during increasing income and on the contrary the Composition and Technological effect cause a reduction of pollution and push curve downward even during ongoing economic growth.

Figure 2: Scale, Composition, and Technique effects



Source: Kaika et al.,2013, p.1396; edited by author.

The relationship between economic growth and environmental degradation continue to be dealt by other authors. For example, Panayotou (1993, p. 2) has mentioned other factors on which the level of environmental degradation depends on.

The level of environmental degradation may be affected by the level of economic activities or **size of the economy**. In low-income countries, the share of industry representation in the economy is small, the economy is mostly represented by the agriculture sector. Industry in the middle-income countries is said to be represented especially by heavy steel, pulp and paper, and chemical industries. Thus, the level of energy consumption and emission generation will rise with the level of economic development. Meanwhile, in higher income countries the share of industry is stabilized, and the sector is dominated mostly by sophisticated technologies and services that produce fewer emission per unit.

An impact on environmental degradation is not only caused by a discharge of substances into nature but also by the way of natural resources depletion. Therefore, the ratio of agriculture, industry, and services represented in the economy has also its impact on the quality of the environment. That may be explained as follows: In the early stage of economic development, countries shift from agriculture sector to industry sector that is known to be a heavy environmental polluter. Thus, in the EKC model, between the pre-industrial and industrial phase of the economy, the upward sloping part of the curve may be observed. The latest phase of economic development is associated with the shift from the industrial sector, which is the most resource intensive sector, to the services sector that is lighter manufacturing and has lower emission per unit output. (Stern, 2004, p. 1419) In fact, growing economy changes industry from minor to a dominant sector as well as from light, through heavy, to highly technologically sophisticated industry. Economies that are heavily dependent on agriculture and other primary industries tend to suffer from a rapid race of resources depletion such as deforestation and soil erosion as well as a low rate of industrial pollution. As a country becomes more industrialized, rural depletion problems become transformed into the urban pollution and congestion problems.

To continue, additionally, above mentioned **structural changes** may also explain the relationship between the EKC's variables and the curve's inverted U-shape. (Panayotou, 1993, p.2) Marsiglio (2015) in its study investigated if the structural change plays some role in generating EKC inverted U-shape. For needs of his research, he constructed a simplified two-sector model of endogenous growth represented by manufacturing and services. Further findings from the simplified model state that negative relationship between income and environment may be a temporary phenomenon. Another economy restart may be characterized by an increase in income and pollution. Thus, Marsiglio's statement is that economic growth cannot be a panacea to fix environmental problems because the relationship between variables is not predictable.

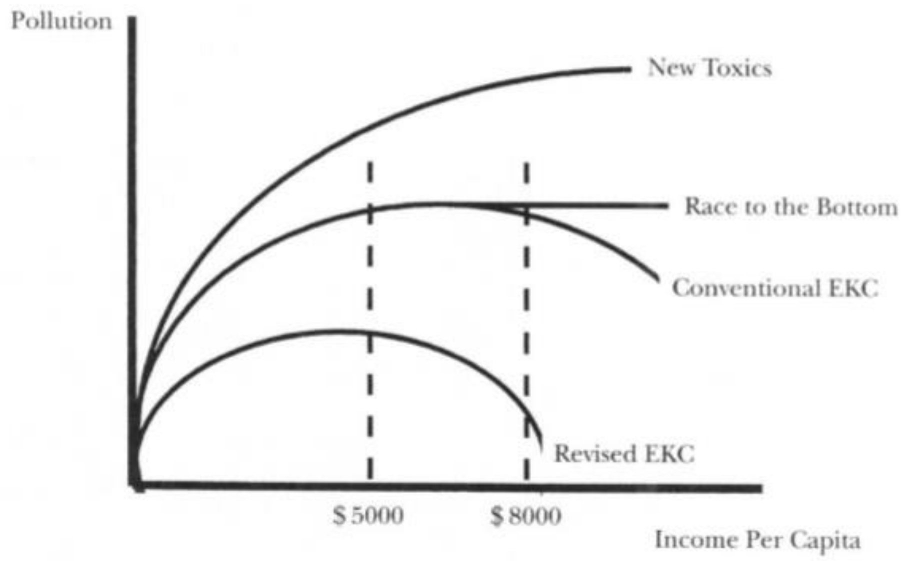
The EKC may be also used as a description of the environmental degradation in relation to the economic development process as well as the reactions of the society or environment on policy decisions about particulate pollutants or environmental areas. Dasgupta (2002, p. 147) perceives the EKC as: "a snapshot of a dynamic process of development" that may achieve two kinds of EKC shapes.

The first scenario is known as **Race to the Bottom effect**. This effect occurs more frequently in developed economies that have relatively more stringent regulation standards, thus, higher polluting activities are facing higher regulatory costs than in developing countries. For this reason, international polluting industries are forced to relocate its production to countries with lower pollution regulations. In fact, the government in high-income countries begins relaxing environmental standards, due to rising capital outflows. Hence, EKC starts to rise and be flatter, owing to the higher existing level of pollution.

The second scenario relates to growing income and **New Toxins creation**. It may be seen that with growing income are reduced particular types of pollutants that are the subject of research. On the other hand, industrial society could create a new kind of pollutants, which are not regulated yet, as the outcome of growing income, knowledge and technologies. Therefore, while, the amount of observed pollutant decreases, the amount of new toxin, which is not research's subject, may begin to grow.

The last scenario **"Revised EKC"** is associated with lowering and flattening EKC that is more discussed in the following chapter. Nevertheless, this phenomenon is caused by the lower amount of pollution in the early stage of industrialization process during economic growth, therefore, the environmental degradation starts fall at the lower income levels. The low level of environmental degradation is caused by several factors that may help to reduce pollution in the early stage of development.

Figure 3: Different scenarios of EKC



Source: Dasgupta et al., 2002, p.148.

1.1.4 Environmental regulations, political decisions and external effects

The main aim of the following chapter is to find out how the government may influence the amount of environmental pollution and how this influence appears in the EKC model. Moreover, this chapter will analyze individual phenomena that may contribute to a lower amount of environmental degradation in the early stage of country development. Consequently, EKC becomes lower and flatter in the early stage of development than conventional EKC. (see Figure 3)

Firstly, the **liberalization of economies**. This process was taking a place in economies over the last two decades during the last century. The first research about liberalization has been issued by Grossmann and Kruger in 1995 who talked about the consequences of reducing trade barriers between Mexico and U.S. market (see chapter 1.1.3). As a consequence of liberalization are reduced government subsidies, privatizing state enterprises, removing trade and investment barriers, and an abolition of price controls. Due to transition from centrally planned to the market-driven economy, the environmental degradation may be reduced faster due to quickly rising energy prices and penalizing of energy-intensive activities. Consequently, the lower and flatten EKC in the early stage of development may be observed.

On the one hand, free trade increases the trade volume, especially exports, that push the economy growth forward, but on the other hand, free trade is a factor that may cause environmental degradation. Thus, as a response to removing trade barriers the Scale effect may be observed, which cause rise environmental degradation, but at the same time, may be seen the regulation of the environmental degradation, owing to the Composition and Technological effects. (see Figure 2)

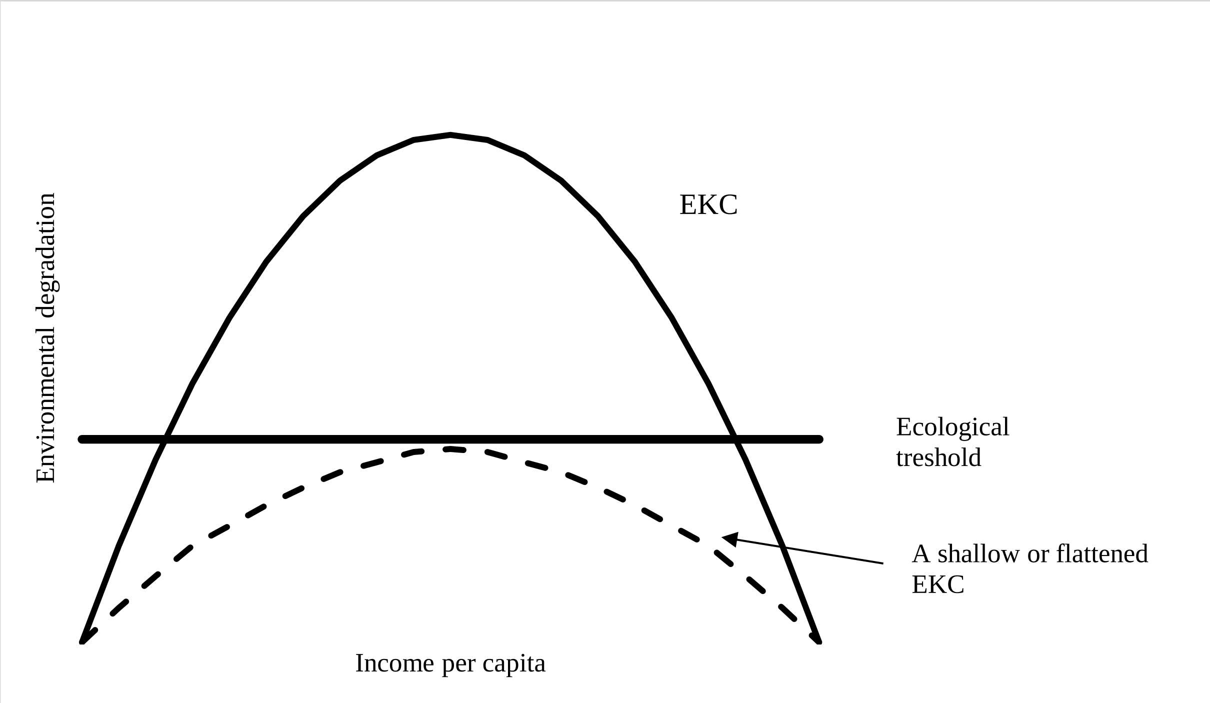
Furthermore, as a response to removal of trade barriers may appear phenomena of **Pollution Haven Hypothesis (PHH)**. Owing to more stringent environmental regulations, which are an outcome of liberalization and free trade phenomena in this case, heavy polluters are forced to move its production to developing countries or to countries where environmental regulations are not so strict yet. As consequences, multinational companies relocate its production to countries with lower standards of environmental regulations. Consequently, in developing countries, the lower and flatten EKC than in already developed countries may be observed.

M.Cole (2004) wanted to find an extent to which the trade patterns influence emissions and if these patterns could be determined by different environmental regulation in developed and developing countries. He found that PHH is only a temporary effect which is further limited to certain regions and sectors. In conclusion, Trade openness was found to have a negative relationship with pollution, thus the PHH assumption may have been proved for a trade of emissions between developed and developing countries.

To continue, gradual development and rising income push developing countries to stricter **environmental regulations**. Since the environment is becoming more significant for the society, owing to rising living standards. The governments are forced to regulate pollution, environmental damages, control local environment quality as well as collect information about polluters that allowed them to enforce other environmental standards. The economic growth is said to be good for the environment, thus, it may tend to suggest that environment does not need any special attention, but all resources should be focused on achieving economic growth, move quickly through environmental unfavorable stages of development to the favorable phase of EKC. This statement is not entirely true, because rapid economic growth without any attention to environment may causes cost and irreversible consequences at a later stage of economic development. As a consequence, Panayotou (1993, p. 15-18) says that: “reverse danger is also possible.” He suggested to developing countries to adopt more appropriate environmental standards of developed countries, for example, environmental taxes, pollution charges, user fees etc. in order to not retard economic growth, but improve the environment immediately in the early stage of development. The environmental regulations effect may be expressed in the EKC model as follow (see Figure 4):

Each country has its own ecological thresholds. Emissions or pollution above these thresholds somehow hurt country's environment and cause other problems for the country. Thus, countries should try to keep emission under this level. The environmental regulations and international cooperation help to achieve this level of pollution since the early stage of economy development. These effects are reflected into the EKC model as flattened or shallow curve of the EKC diagram (see Figure 4).

Figure 4: Environmental regulation effect



Source: Panayotou, 1993, p. 16, edited by author.

In case of weak or absent formal regulations, societies are often forced to use other channels of regulation to regulate environmental damages. (Dinda, 2004) In the absence or ineffectiveness of formal regulations play a key role some form of **informal regulation**, for example, non-government institutions or community groups that are trying to replace formal institutions and negotiate with heavy polluters at their area and trying to create a pressure on them to reduce excess amount of pollutions.

Another element that may influence the level of environmental degradation in the early stage of development are **Market Agents**. In particular, Market Agents represent, for instance, citizens, businesses, policy makers, non-government organizations etc. who react on economic growth. Their reactions may produce side effects and thereby cause pressure on environmental regulation. Usually, Market Agents do not use direct techniques, but create the pressure on environmental regulation by indirect techniques. For instance, customers may decide not to support heavy-polluters anymore, therefore, as an express of their disagreement with heavy-polluting companies start to support environmentally friendly companies. As a consequence, those producers' revenues decline. Hence, they will be forced to change its production policy in order to increase its revenue again that may also involve reduction of air pollution by production.

Not only customers but also bankers can express a certain disagreement by not wanting to provide extra credits. In addition, also for investors heavy emissions may signal inefficient production technologies and potential losses from regulatory penalties, thus, they may decide not to invest into these companies or cooperate with these producers. (Dinda, 2004)

In recent years, the quality of **environment information** in developing countries has also become better. Due to collecting information by public and non-public institutions is create a pressure on environment improvement by public agents, and programs providing accessible public information about polluters, pollution damages etc. According to comprehensive information about environment, creators of public environmental regulation are able to set up better comprehensive environmental regulations that accurately reflect needs of environment in the country and thus diminished environmental degradation.

International assistance also plays an important role in shallowing and flattening the curve in the EKC model. The international assistance may help to reduce pollution due to providing easily accessible information about polluters, local environment, supporting policy reforms collect information or provide public environment education. For example, it was found that EU Cohesion Policy through technology and structural alteration in period 2003-2007, helped to reduce GHG especially in those countries where the GDP growth was not growing as fast as in rich EU members. Therefore, it was recommended to countries where the amount of GHG was still increasing to follow the best practices of those countries, where GHG had already declined. Liobikiene (2015)

The following Table 1 summarizes the finds on selected studies that have been dealing with above mentioned external effects and hypothesis. Some of the results of these studies have already been mentioned in previous chapters

Table 1: EKC hypothesis

Authors (years)	Issues	Sample	Results/ Outcomes EKC
Simon Kuznets (1955)	Relationship between economic growth and income distribution	The United States, England, Germany	Relative income distribution tends to equality between societies.
T. Panayotou (1993)	1. Environmental pollution and level of development. 2. EKC and policy implications.	Develop and developing countries	Hypothesize inverted U-shape relationship between the rate of environmental degradation and the level of economic development.
Gene M. Grossman, Alan B. Krueger (1995)	EKC and Direct investments/ liberalization	Mexico and USA	Discussion of scale effect, composition effect, technological effect that affect the level of environment pollution and a process of economy development.
E. Magnani (1999)	EKC and policy protections.	High-income OECD countries (1980-1991)	Not sufficient growth of service sector and an inability of manufacturing sector increase productivity through technological development may cause that EKC will not take a place in the model. Moreover, EKC is said to be a temporary phenomenon.
M.A. Cole (2004)	Trade openness, structural change, and Pollution Haven Hypothesis	USA, Asia, Latin America, UK, Japan; different the most pollution intensive sectors	Share of manufacturing (industry-economy stage) output has positive relationship with pollution; *Trade openness* has negative relationship with pollution. It may be caused due to increasing competitiveness and resource efficiencies or by better access to greener technologies. Higher income levels: – Increasing demand for environmental regulation. – Increasing investments in abatement technologies. – Structural change as an outcome of declining share of manufacturing outputs, and increasing imports of pollution intensive outputs.

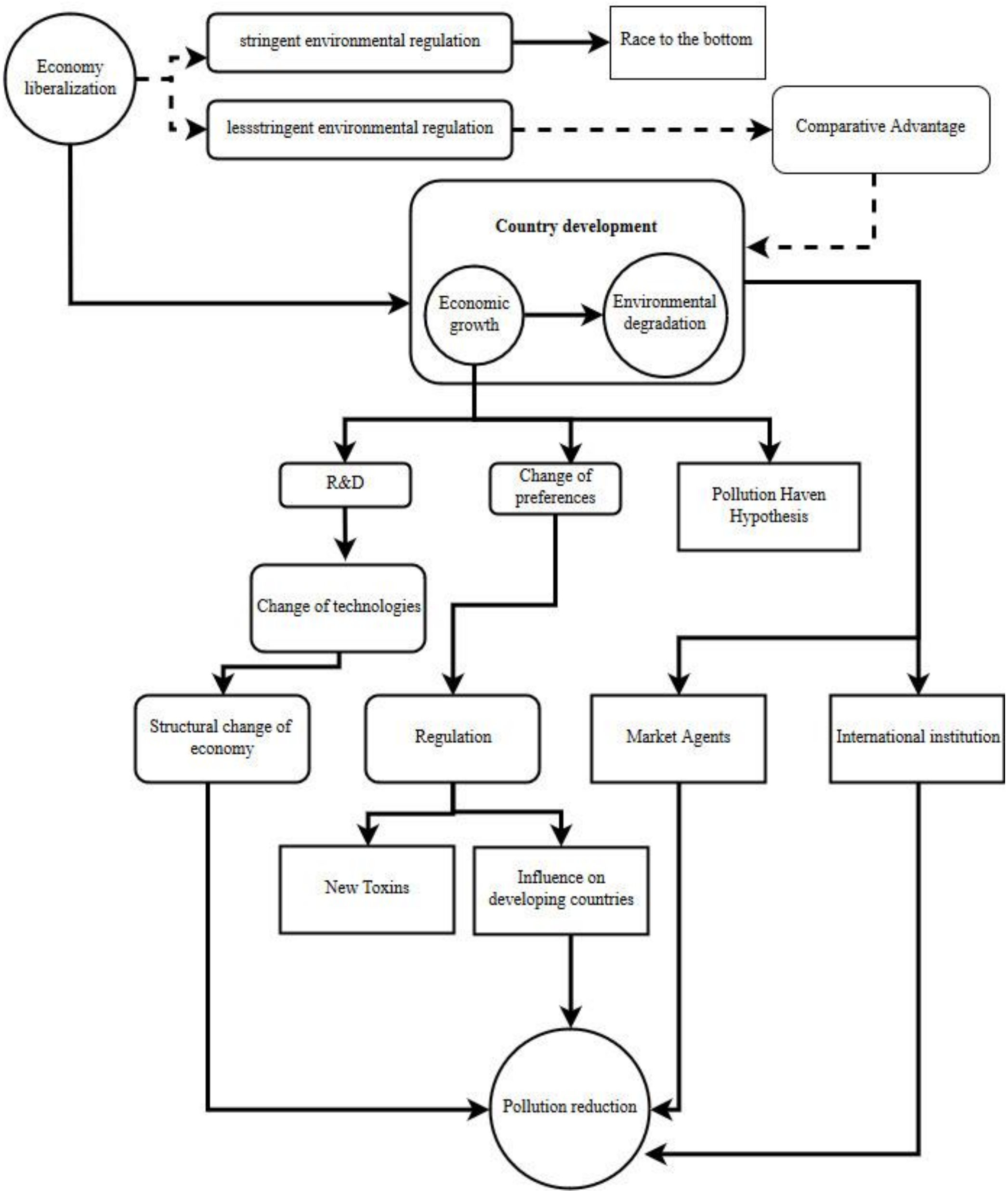
T. Bernauer, V. Koubi (2008)	EKC and political institutions	107 cities from 42 countries (1971-1996)	A positive relationship between a degree of democracy and amount of pollution. A negative effect of labor unions strength on the level of pollution and a positive effect of green parties' strength contributing to higher environmental quality. In presidential democracies were found a cleaner air than parliamentary democracies.
S. Managi et al. (2009)	EKC and trade openness	OECD and non-OECD countries	Impact of trade openness on the environment in the context CO2 and SO2 polluters: - depend on pollutants and countries Negative effect in non-OECD countries - The comparative advantage in labor-intensive production and enforce relatively lax environmental policies. Positive effect in OECD countries - The comparative advantage in capital-intensive production and enforce relatively strict environmental policies.
S. Marsiglio (2015)	EKC and Structural changes (EKC U-shape as a result of structural change)	EU-25	Possibilities of structural change: International trade liberalization Carbon taxes (public policy) Structural change may be only temporary phenomenon (restart of economy => increasing income and pollution). Therefore, GDP growth is not a panacea of fixing environmental problems.
G. Liobikiene (2015)	EKC and Regulations	25 EU countries (The Czech Republic, Finland)	EKC did not occur for EU countries Positive, neutral, and negative changes in GHG emissions in relation to Cohesion Policy were found in EU countries. The largest GHG emission reduction was found in Finland. Technological progress was found to be largest in EU countries with the fastest GDP growth rate. Economic growth does not have a large impact on economic structural change to GHG emissions reduction. (the most contribution of structural change to GHG emissions reduction was found for the Czech Republic) Renewable energies have a large influence on GHG emissions reduction.

	Indirect link between R&D and GHG emissions. Reduction impact on GHG emissions is on when new developed technologies are implemented.

Source: Author.

The first chapter introduced external effects and hypothesis which relate to economic and social conditions in the Czech Republic and Finland. These effects have been found to be the most appropriate that may influence EKC regression analysis outcomes and its variables in the third chapter. An overview of all above mentioned effects is summarized in the following chart (see Figure 7). It should express how the individual effects respond to each other and the way how they can improve environmental degradation.

Figure 5: External effects and EKC hypothesis



Source: Author.

1.2 EKC studies on CO2 and SO2 pollutants

The main aim of this chapter is to analyze the conclusions of studies that have been conducted from the early 1990s to the present and which provide an overview of the testing EKC validity. Regarding to this study, the main interest is based on testing validity of EKC on CO2 and SO2 pollutants in two European countries. Therefore, the following studies have been selected as the most relevant to these countries or these countries have been directly included in particular studies.

Since testing EKC hypothesis in the Czech Republic is not so frequent, studies that would provide relevant results of testing EKC hypothesis and could be used for this thesis are not known. One of the study investigated the EKC hypothesis on the case of CO2 a SO2 pollutants in the Czech Republic is study from Hercegova issued in 2011. This research did not prove the EKC hypothesis for CO2 pollutants, but confirmed EKC hypothesis on SO2 pollutants.

J. Kunnas, who published a study on the EKC hypothesis testing on CO2 a SO2 pollutants in the period 1800 – 2003, studied the EKC hypothesis in Finland. He was testing if gass emissions of energy production follow an inverted U-shape curve related to income. For CO2 emissions from energy production was found increasing tendency at the beginning of the period, but a decline at the highest level of income was not found, therefore, for CO2 emissions the EKC hypothesis was not proved. The energy consumption was steadily increasing with increasing income. During observation were found two events that influenced trend path. The first is associated with the oil crisis, when the oil price rapidly rose, which also affected energy consumption. Later, when the price fell again, energy consumption rose again to its trend path. The second drop in energy consumption occurred between years 1990 – 1993, when GDP decreased, and energy consumption growth stopped as well. When, in 1994, GDP started to grow again, the energy consumption began to rise too. Hence, the regression-related items did not confirm the conditions for demonstrating the validity of the hypothesis, therefore no support for the EKC hypothesis considering energy consumption was found. On the other hand, the correlation for the cubic regression was found with a turning point at 20 700 dollars. The decline between years 1996 to 2000 was followed by a sharp increase in emissions from 2000 to 2003. Hence possible support for EKC hypothesis exists between two above mentioned periods, but as Kunnas said: “Our conclusion is that it is too early to say which is the case.” Moreover, the study also considered the stock price of fossil fuels development. There was found an increase in the standing stock price in the 1950s, due to extensive forest improvement program that was practiced in Finland.

The study also investigated sulfur dioxide that causes acidification. The first sign of acidification in Finland was noticed in the 1970s. In 1980 was opened a forecast considering the impact of this effect on Finland’s forests mainly in Lapland area. Thus, it was decided to reduce sulfur and nitrogen emission by between 70% to 90% that, as it turned out later, helped to prevent a disaster on the forests in Lapland as well as a decline of SO2 emissions. Secondly, the drop in SO2 emissions was caused by fuel choice, owing to replacing heavy fuel oil and by using coal with low sulfur content. To conclude, the regression for SO2 emission demonstrated U-shape EKC hypothesis with the turning point at 15 000 dollars for fossil fuels and 10 000 for fossil fuels and industrial processes. The decrease of SO2 emission could be also caused as a by-product of technical changes dictated by economic reasons, moreover, these changes increased economic growth due to improved competitiveness through resource savings and green goodwill. (Kunnas, 2007, p. 18)

The Table 2 shows that studies mostly confirmed a direct relationship between CO2 and the income per capita than EKC hypothesis. These conclusions may be influenced by data for which the studies have been done because the countries could have been in the growing part of the EKC for given period. Furthermore, some of the studies included external factors in the regression model that could also have a significant impact on outcomes.

Richmond and Kaufmann (2006) analyzed the relationship between income per capita and energy use (is associated with an occurrence of CO2 emissions). They found no evidence about the turning point for given data and countries, therefore they only proved a direct relationship between these variables. In addition, they have said that fuel mix and level of economic development may affect the property of the turning point. Owing to no evidence of turning point they have also suggested that environmental policy decisions should not be dependent on this relationship and its turning point.

Iwanta (2011) has involved a factor of nuclear energy into the standard EKC hypothesis. The statement is: The production of electricity by nuclear power may reduce CO2 emissions. Neither the EKC hypothesis has been proven in this study nor the impact of nuclear energy on CO2 emission reduction.

To continue, the presence of EKC hypothesis has been proven only for one of the seven arctic countries in Baek's (2015) research. For the rest of the countries the N-shape curve has been found. The energy consumption was used as an external factor of EKC hypothesis which was found to have an adverse effect on environment, in other words, energy consumption tends to increase carbon emissions in the most countries.

The Beck's study (2015) has proven the EKC hypothesis for selected non-OECD countries. On the contrary, for OECD countries the N-shape curve has been found, however, it was not excluded that the EKC cannot be find for individual counties. Beck explains the occurrence of the N-cure in OECD countries as follows: *"People and government became more willing to accept higher amount of carbon emission, due to desire an elevated standard of living or they want to emphasize continual economic growth above the environment."* (Beck, 2015, p. 40) As external factor, the population growth was involved in this research, which was not found to be a variable that would have an impact on amount of emission. Secondly, the trade openness that had also a little impact on level of pollution especially in OECD countries, owing to better and cleaner technologies for production and emissions abatement. In comparison with OECD countries, the impact of trade openness in non-OECD countries performed increase of CO2 emissions. The increase of CO2 emissions may be connected to PHH. Unlike previous study, Beck found negative relationship between energy use and CO2 emissions. Increasing use of energy cause decrease amount of CO2 emissions in OECD countries at the same time, due to use of alternative sources of energy. Primarily, this conclusion points out that developed countries should transfer their technologies, knowledges, or financial assistance into developing countries and help them to reduction of global CO2 emissions, hence, it may also lead to lower and flatten their EKC.

Dogan's study dealt with the issue of renewable and non-renewable sources of energy and their impact on the level of environmental degradation as well as on EKC hypothesis. The renewable energy was found to have a positive impact on the environmental degradation. He also confirmed positive effect of trade openness which is explained as benefits of already developed countries and their advanced technologies due to that they may benefit from the trade and technology spillover. Consequently, it may be seen that top renewable countries produce export predominantly non-energy intensive products and import "dirty goods". Dogan also concluded that developing countries should be supported by developed ones.

Table 2: EKC studies on CO2 emissions

Author (year)	Data	Time Horizon	Depending shape
Shafic and Bandyopadhyay (1992)	149 countries	1960-1990	↗
Roberts and Grimes (1997)	Low-middle-high-income countries	1962-1991	∩ (high income), ↗ (low/middle income)
De Bruyn et al. (1998)	Netherlands, Germany, UK, USA	1960-1993	↗
Galeotti and Lanza (1999)	110 countries	1970-1996	∩
Panayotou et al. (2000)	17 developed countries	1870-1994	∩ (panel data), ∩ US, UK (time series)
Azomahou and van Phu (2001)	100 countries	1960-1996	↗
Lindmark (2002)	Sweden	1870-1997	∩
Cole (2004)	21 countries	1980-1997	∩
Richmond and Kaufmann (2006)	36 countries	1973-1997	↗
Kunnas and Myllyntaous (2007)	Finland	1800-2003	↗
Coondoo and Dinda (2008)	88 countries	1960-1990	∩ (Europe), ↗ (for all)
Dutt (2009)	124 countries	1960-2002	↗ (1960-1980), ∩ (1984-2002)
Narayan and Narayan (2010)	43 developing countries	1980-2004	∩ 15 countries (time series), ∩ (Middle East, Asia - panel data)
Iwata et al. (2011)	28 countries, (17 OECD countries)	1960-2003	↗

Jaunky (2011)	36 high income countries	1980-2005	∩ (5 countries), ↗ (whole panel)
Andreoni (2012)	EU27	1996-2008	↗
Shahbaz et al. (2013)	Turkey	1970-2010	∩
Kasman et al. (2014)	New EU member	1992-2010	∩
Mazur, Phutkaradze, and Phutkaradze (2015)	28 EU countries	1992–2010	↗ (28 EU), ∩ (16 EU)
Bilgili et al. (2015)	17 OECD	1977-2010	∩
Shahbaz et al. (2015)	99 countries; high income, middle income, low income	1975-2012	∩ (middle-income countries)
Beck et al. (2015)	OECD and non-OECD Countries	1980-2008	N shape (OECD), ∩ (non-OECD);
Baek (2015)	Arctic countries	1960-2010	∩ (Island), N-shape (Canada, Norway, Denmark, Finland, Sweden, US)
Kais (2016)	58 countries	1990-2012	∩
Dogan et al. (2016)	40 countries	1985-2011	∩ (Top renewable energy countries)

Source: Source: Kaika et al. 20013, p. 1398-1400, edited by author.

The following Table 3 presents studies on SO2 pollutants, conclusions differ from the above-mentioned finds of studies on CO2 pollutants. If we compare finds of these two tables we would conclude that the frequency of occurrence EKC hypothesis on SO2 pollutants studies is higher than on CO2 pollutants. These outcomes may be a consequence of cost-effective solutions for local or regional environmental effects that relate to SO2 emissions. On the contrary, the global environmental effects, like global warming, which is relate to CO2 emissions, do not have cost-effective solution, therefore, these pollutants do not confirm the EKC hypothesis as often as SO2 pollutants. (Kunnas, 2007, p. 120-121)

EKC hypothesis was tested on CO2 and SO2 pollutants data for the Czech Republic during the period 1990-2009. For CO2 pollutants the hypothesis has been rejected, due to not so strong pressure to internalized externalities as on SO2 pollutants. (Hercegova at al., 2011)

The EKC hypothesis also relate to defining the turning point (TP). In other words, to find the amount of per capita income at which the amount of pollution starts declining with rising income per capita. Marakynda et al. (2006) found in his study that environmental regulations had shifted TP to the left in 11 countries including Finland. It means that environmental pollution started to fall at the lower income per capita that before environmental regulations. Moreover, it was confirmed that EU and international directives flattened EKC in particular countries. The higher TP and significant impact of SO2 emission than CO2 emissions was found in developing countries by Sayed (2013) during period 1961-2009.

Table 3: EKC studies on SO2 emissions

Author (year)	Data	Time Horizon	Depending shape
Selden and Song (1994)	30 countries	1979-1987	EKC
Grossman and Krueger (1995)	32 countries	1977,1982, 1988	EKC
Panayotou (1997)	30 countries	1982-1984	EKC
Torras and Boyce (1998)	42 countries	1977-1991	N curve
Stern and Common (2001)	73 countries	1960–1990	The breaking point of EKC was higher for developing countries
Millimet et al. (2003)	USA	1929–1994	EKC
Bertinelli and Strobl (2005)	108 countries	1950–1990	Rather monotonous
Markandya et al. (2006)	12 western European countries	1850-2001	EKC
Kunnas (2007)	Finland	1800-2003	EKC
Kumar (2010)	51 developing and developed countries	1971 2000	EKC
Hercegova et al. (2011)	The Czech Republic	1990-2009	EKC
Fosten et al. (2012)	UK	1751-2007	N curve
Wang (2012)	19 OECD	1870-2001	EKC
Sayed (2013)	40 countries; 2 groups (developed and developing countries)	1961-2009	EKC; The breaking point of EKC was higher for developing countries
Rafaj et al. (2013)	39 countries in Europe (East and West part of Europe)	1960-2010	EKC
Georgiev and Mihaylov (2014)	30 OECD countries	1990 2005	EKC
Liddle and Messinis (2015)	25 OECD countries	1870-2005	19 countries EKC (Finland)

Source: Tsurumi et al., 2010, p. 23, edited by author.

2 ENVIRONMENT AND ENVIRONMENTAL POLICY

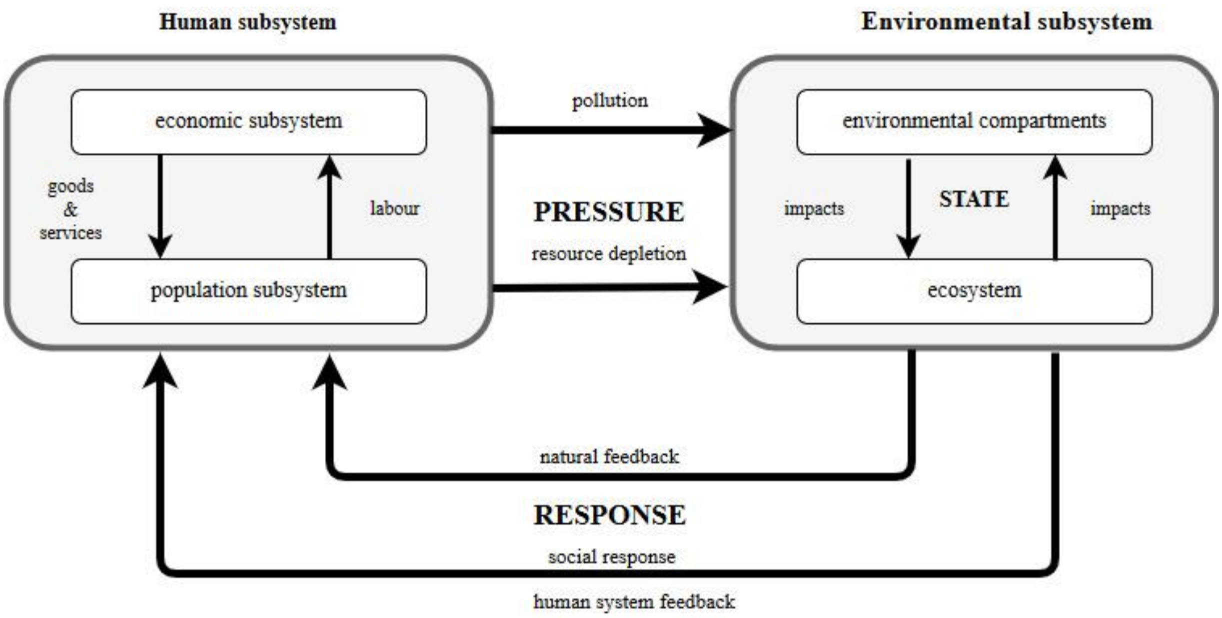
Environment, in the context of environmental economics and environmental policy is perceived as a *good* that has ability to meet human needs. Environmental pollution belongs to undesirable good. (Čamrová et. al, 2012, p.30-32) All goods are free and available for whole society until the time when people start to increase the needs of this good or the availability becomes scarcer. Due to natural resource deletion the goods become rare due to, for example, population growth, or technology development and better use of the good etc.

Since the environment as well as the air is a public good, the so-called *'free riding problem'* may be observed. Especially during negotiation of environmental regulations, because countries perceive small possible cutbacks in their own amount of emissions in comparison with other countries. Therefore, in accordance with the international co-ordination, it is necessary to precede so-called *'prisoner's dilemma'*. (Kunnas, 2007, p. 121)

To continue, due to the air or the environment characteristic, the government may also meet with so-called *'tragedy of commons'*. It may be cause due to lack of rights specification or obligations relate to use of natural resources. Therefore, it is necessary to regulate the environment or individual part of the environment to avoid this effect and its disastrous consequences on the environment.

The following Figure 6 describes how the interactions and responsibilities between Human subsystem (HS) and Environmental subsystem (ES) work. As it has been already mentioned, the interactions in the Human subsystem between economic subsystem and population subsystem create a pressure to the Environmental subsystem through pollution and resource depletion. Therefore, the environmental regulations should mitigate the environment's response on pressure creates by HS. Thus, the existence of regulator is important as prevention of non-renewable environmental disasters.

Figure 6: Human and Environmental subsystems interactions



Source: Hammond, A.L. (1995, p. 11); edited by author.

In the middle of 20th century, the society has begun to be more interested in air quality and its conditions. Later, between the 80s and the 90s, has appeared also the discussion about climate change and its probable causes and side effects. Nowadays these two policies are considered separately. The SO2 pollutant is one of the most polluting elements of the air. Furthermore, this pollutant has also an impact on clime change as a component of aerosols.

Therefore, for the needs of this thesis will be considered both policies - air policy as well as climate change regulations.

2.1 Schools of environmental economics

In relation to environmental economics, many schools of economic thought that perceive environmental issues differently may be found.

Neoclassical environmental economics perceives environmental degradation as a consequence of market failure which is caused by public goods and externalities. The only one who can prevent decreasing quality of the environment is the public environmental policy via taxes, at that point, so-called internalization of externalities takes place. Owing to that, market equilibrium is recovered again, and the resource allocation is re-optimized. Representatives of this school say that public goods should be provided by a public sector that is able to avoid so-called 'free-rider problem'.

Follower of neoclassical environmental economics idea is *Ronald Coase*, which extends environmental tools by bilateral bargaining between the polluter and the injured, its premise is: well-defined property rights and low transaction costs of negotiations.

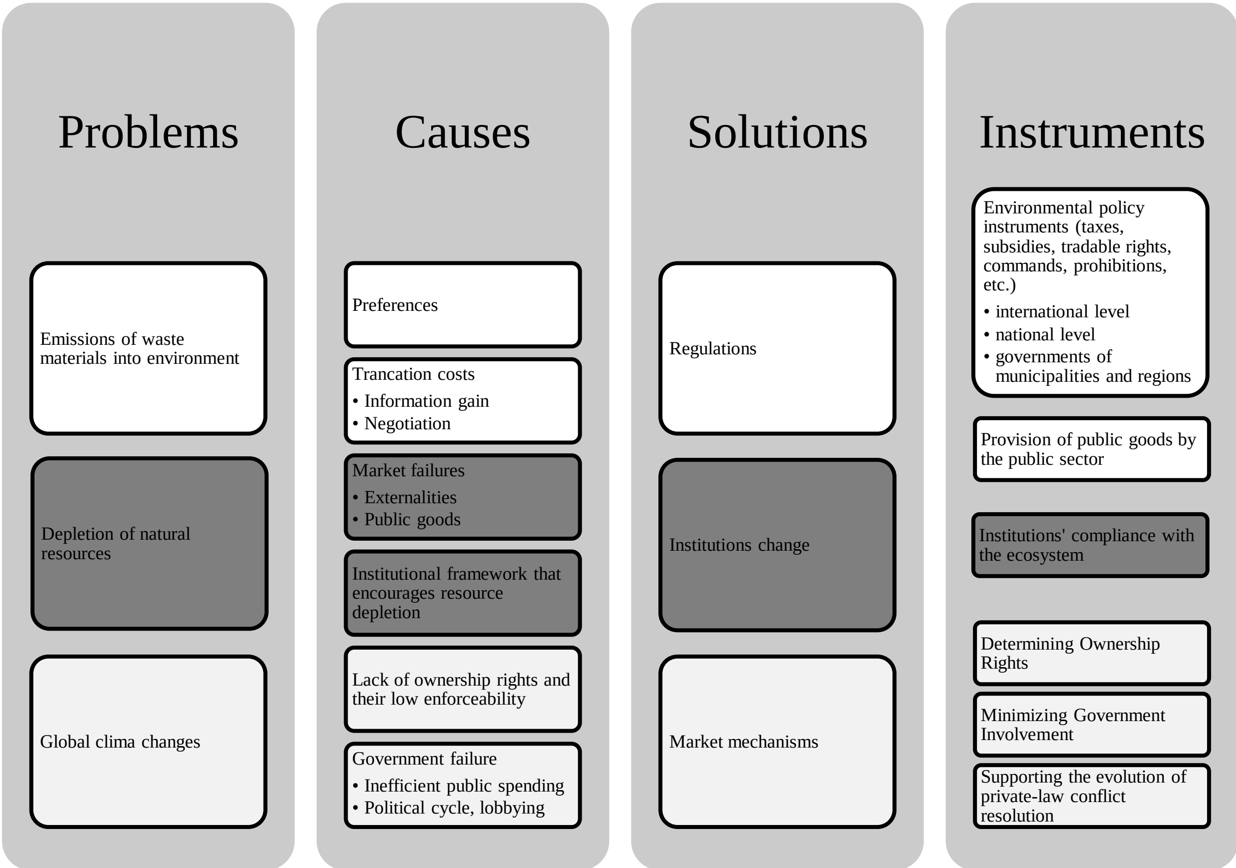
On the other hand, *ecological economics* sees causes of environmental degradation in the individual's motivation and behavior towards nature, because individual preferences do not reflect the true value of ecosystems. Possibilities of a solution are perceived through the government that is able to recognize the natural sciences knowledge and promotes a sufficiently sustainable environmental policy to reduce environmental degradation and protects the environment.

Institutional environmental economics find causes of environmental damage in poorly set institutions that motivate individuals to deplete natural resources. Thus, to sustainable use of natural resources a proper adjustment of institutes is required. Moreover, into decision-making process should be involved direct resources users at the local level.

Different approaches to the causes of environmental degradation are held by *market approaches*, that see the main causes of government regulation and the provision of natural conditions by the public sector and exclude the use of market mechanisms. The solution is seen in property rights definition of environmental goods, owing to that the owner strives for a long-term appreciation, use of these goods belongs only to those for which environmental goods have the greatest value.

For the purposes of this work, we will focus on the two environmental problems outlined in Figure 7. The problem of emitting waste material into the environment may be caused by the change of society's preferences which may be observed, for example, in the Beck study issued in 2015 (see chapter 1.2). The global climate change problems may be caused owing to lack of ownership rights and their low enforceability or government failures. Solutions to these problems may pose market mechanisms, for example, determining the ownership right or minimizing the government involvement etc. More problems, causes, and solutions may be found in the following Figure 7.

Figure 7: Causes of environmental damage and their possible solutions according to different theoretical approaches



Source: Čamrová et. al, 2012, edited by author.

2.1.1 Environmental Policy tools

The main aim of this chapter is to present appropriate environmental policy instruments and measures used to regulate and control environmental degradation in particular country. The policy uses a variety of tools that can complement each other, but also act contrarily. Thus, it is generally recommended to use a mix of various instruments to meet an environmental target.

Each of instruments may vary due to form of *stimulation* or degree of *defectiveness*. *Stimulation* instruments may subject motivate to protect environment above the level of environmental regulations by financial subventions or punish subjects if the limit is not meet.

The rate of *directivity* can be observed, for example, in the so-called *administrative tools*, which are based on the coercing of the subject to regulate the environmental impact such as commands, prohibitions, standards, limits and quotas, mandatory procedures and technologies, and subject cannot legally avoid them. On the other hand, *economical tools* allow subjects to choose how to act to protect the environment. They influence subject's behavior by its cost and expense functions. The most used economic tools are taxes and fees. They may be labeled as a payment for negative externalities of production or activities towards the environmental degradation. This applies particularly to discharge of solids into the air or consumption of specific substances that contributes to the pollution increase. Compared to taxes and fees, subsidies are intending to encourage activities beneficial to the environment or supporting cut costs on pollution reduction. As an example, government spending on the environment, subsidies, tax incentives and financing institutions may be mentioned. Another instrument belongs to economical tools are *tradable pollution permits* that are based on direct regulation of particular pollutants or natural resources. (Čamrová, 2012) This tool is widely used in the European Union.

2.2 International environmental regulations

The main objective of this chapter is to highlight the main environmental regulations, primarily issued in period 1990-2014. Give that both Finland (1995) and the Czech Republic (2004) are member of the European Union, thus, the main attention will be mainly focused on directivities issued by EU.

At the beginning of EU regulations, the first piece of the environmental defectiveness was focused on road vehicle emission in the 1970. However, the response on air quality was not as prompt as was expected. Later, the first directive on the sulphur content of gas oil (mostly used for domestic heating) was issued in the 1970s.

In June 1988 was reached an agreement on the directive on large combustion plants. This legislation is perceived as a response to acidification that set emission limits for SO2 and other pollutants and dust for existing and new plants. The main goal was to cut SO2 emission by 58% in three phases by 2003 (1980 baseline). In 1993 the greatest reduction's outcome came from the three countries – Austria, Finland, and Sweden, which did not join the EU till 1995. The reduction outcome was achieved by the use of low-sulphur coal and fuel gas desulphurization technology, a switch from coal to gas, and the renewal of power plants. (McCormick, 2001, p. 228-231)

The theory of GHG effect has been known since the end of 19^{th} century. Although, the main attention on GHG emission was paid on the first World Climate Conference in Geneva, which was attracted little political attention. Moreover, the Commission before the Earth Summit had decided to take more interest in the issue improving energy efficiency and to promote the use of renewable energy. In 1992 was hold the Earth Summit where developed countries have agreed to reduce their CO2 emissions back to 1990 level by the year 2000. However, initially were discussed different CO2 reduction targets for different member states was finally abandoned and replaced by three-part 'climate package'. This replacement involved greater energy efficiency and renewable energy use. Secondly, there was a need to adopt some monitoring mechanism that allowed to develop and implement national programs for CO2 reductions. Lastly, the most controversial issue was a carbon tax. However, many countries had already implemented these taxes since the 1990s. Finally, the Council decided to drop the ide of taxes and allowed member states to develop their own taxes. (McCormick, 2001, p. 280-290)

Finland was the first country that implemented carbon taxes as an instrument for climate change mitigation in the early 1990s, even before than joined EU in 1995. Originally, the tax was based on based the carbon content of the fossil fuels. In that time the peat represented an abundant energy resource in Finland. Also, the wood industry represented export-oriented industry which had the comparative advantage. Hence, on peat, which poses relatively less know an energy source, and wood industry were levied on a favorable tax treatment. In that time, the peat was considered as biofuel different from fossil fuels. Although, in fact, the peat emits the same amount of CO2 as coal per unit of energy. Later, the carbon tax system was reformed and were adjusted accordingly among tax of carbon and energy taxes. Nowadays the Finnish carbon tax system is perceived as one of the world's effective carbon tax rates.

For the year 2018 Finland wants to introduce a new law increasing carbon taxes, and strategy to get rid of coal as an energy source by 2030. Therefore, Finland needs to find alternative energy sources to keep its power system stability. Nuclear power as an alternative source of energy provides currently only 10% of Finland's power. In the near future, two new reactors are due to be open. Hence, about 60 % of Finland's energy needs will be met, the rest of energy needs will be filled with coal and other alternative energy sources. (Investingnews, © 2017)

In 2005 EU started with the Emission Trading System (ETS). The main reason for emission market creation was to meet the Kyoto Protocol commitment, where EU members committed to reducing the amount of GHG emissions.

How ETS market works? The system is based on the *'cap and trade'* principle, where a total amount of emissions (one tone of emission represents one emission allowance) determine the

ETC market. After that, these tradable allowances are divided between polluters, used permits are then eliminated from the market. The allocation of permits can be done in three ways. The EU ETS is now in the third phase (2013-2020), which is defined by many changes in the system. One of them is a change of allocating permits method – EU wants setting auctioning as the default method for allocating permits. The second change concerns including more sectors and gasses into the trading system and many other changes. However, the system is known for its ineffective, because the price of permit was not as high as had been originally anticipated. Thus, EU was forced to resolve this system and to re-enforce its effectiveness and motivation nature.

When in 2003 European Commission issued Council Directive 2003/96/EC which is a framework for the taxation of energy products and electricity. The main objective of the Directive was to extend minimum rates of taxation to energy products. The Czech Republic received an exception and the directive could have been introduced till the year 2008. The environmental tax reform had three phases in the Czech Republic.

Not only Finland but also in the Czech Republic the government discussed the possibility of introducing carbon taxes as an addition to the existing EU ETS. Although the first proposals for tax implementation in sectors out of EU ETS were in 2014, the taxes did not come into effect. Nevertheless, in 2017 the new climate strategy and anti-fossil fuels law were approved in the Czech Republic. The strategy addresses climate protection by 2030 and gradual transition to low-emission economy by 2050. Moreover, this new strategy also considers cooperation with other sectors for achieving GHG reduction. For example, in the energy sector, the Czech Republic wants to be focused on renewable resources and higher energy efficiency. Transition to low-emission economy needs a stable financial support, thus, the government started to consider carbon taxes as another financial source along with EU ETS, and European structural and investment funds. (Ministry of the Environment, ©2008-2015)

3 EMPIRICAL TESTING OF EKC: THE CASE STUDIES FOR THE CZECH REPUBLIC AND FINLAND

3.1 EKC Model and data

For the purpose of this thesis, the EKC linear and non-linear regression model will be used. The regression analysis is used to test the various possible relationship between pollution level (dependent variable) and income per capita (independent variable). It is also used in situations where we want to know the dependence of a certain quantitative variable on other quantitative variables.

In the Grossman and Krueger's first EKC study a simple cubic function of per capita levels has been estimated. Later, other studies investigated also quadratic function for EKC model. Moreover, many other studies were dealing with other external factors influencing the EKC hypothesis outcome. Therefore, these factors were also included in the EKC model as other variable entering the EKC model. Stern (2004, p. 440) used the following reduced model to test the various possible relationship between pollution level and income:

$$\textbf{[1]} \quad \boldsymbol{Y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \varepsilon}$$

Where Y_i represents dependent variable and x_i represents independent variable (income per capita). β_0, β_1 , β_2 are unknown regression function parameters and ε is a random deviation.

Above mentioned model [1] allow to test several forms of environment-economic growth relationship. Nevertheless, the regression function parameters may influence the EKC model shape. The possible EKC model outcomes and its curvature may be as follow. Stern (2004, p. 440-441):

a) $\beta_1 > 0 \; and \; \beta_2 = 0$ means a monotonic increasing relationship or a linear relationship between x and y.

b) $\beta_1 < 0\ and\ \beta_2 = 0$ means a monotonic decreasing relationship or a linear relationship between x and y.

c) $\beta_1 < 0\ and\ \beta_2 < 0$ means an inverted U-shape relationship (EKC).

d) $\beta_1 < 0\ and\ \beta_2 > 0$ means a U-shape relation.

3.1.1 Regression analysis model

Akbostancı et al. (2009, p. 863) claimed that investigated dependence relationship is basically a function of GDP, where E stands for the tested environmental indicator and GDP is gross domestic product.

$$\textbf{[2]}\ \boldsymbol{E = f(GDP, GDP^2)}$$

If the function [2] is inserted into the quadratic regression model [1], the following equation [3] may be obtained. Where E_i indicates a value of the environmental indicator for given year.

$$\textbf{[3]}\ \boldsymbol{E_i = \beta_0 + \beta_1\, GDP_i + \beta_2 (\, GDP_i)^2 +\ \varepsilon_{\,i}}$$

For the purpose of this thesis, the EKC model and its variables are conceived on per capita. Thus, the model variables will be adjusted to per capita variables, where P is population for given year. Thus, the in the following equation [4] $\left(\frac{GDP}{P}\right)_i$ is an income per capita in a given year and $\left(\frac{E}{P}\right)_i$ is a pollution per capita in a given year.

$$\textbf{[4]}\ \boldsymbol{\left(\frac{E}{P}\right)_i = \beta_0 + \beta_1 \left(\frac{GDP}{P}\right)_i + \beta_2 \left(\frac{GDP}{P}\right)_i^2 +\ \varepsilon_{\,i}}$$

In addition, for testing the EKC model will be also used the linear regression analysis [5] where $\beta_2 = 0$:

$$\textbf{[5]}\ \boldsymbol{\left(\frac{E}{P}\right)_i = \beta_0 + \beta_1 \left(\frac{GDP}{P}\right)_i +\ \varepsilon_{\,i}}$$

For finding the EKC model maximum – turning point (TP) will be used modification of the regression model [5]:

$$\textbf{[6]}\ \left(\frac{\mathbf{GDP}}{\mathbf{P}}\right)_{\mathbf{EKC}} = \frac{\boldsymbol{\beta_1}}{-2\boldsymbol{\beta_2}}$$

where the right side represents the amount of the GDP per capita that equals the EKC turning point.

3.2 Data

Fort the purpose of this thesis were used data on CO2 emission, SO2 emission, GDP and population for Finland and the Czech Republic in period 1990-2014. In order to achieve the main thesis' objectives, it was necessary to work with suitable databases that provide the required information. Therefore, The OECD statistics, European Environment Agency and Eurostat served as a main data source.

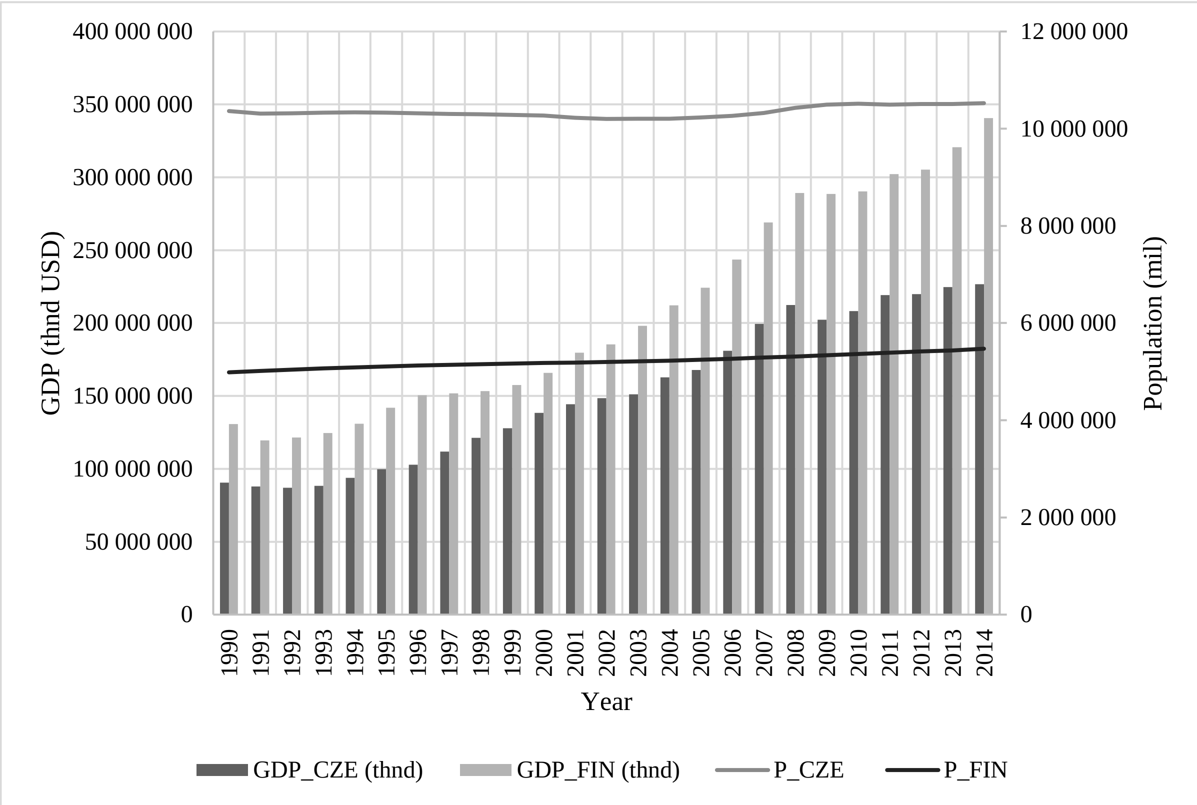
3.2.1 Gross domestic product (GDP)

Gross domestic product (GDP) is used as an indicator of countries' wealth in the EKC model. For needs the EKC model, GDP is expressed in quadratic [4] and linear [5] regression model as GDP per capita**.**

The following Figure 8 shows increasing trend of GDP between period 1990-2014 in the Czech Republic and in Finland. The data indicate that GDP growth was higher between years 2004-2008 in the Czech Republic than in previous years. That could have been caused by the join the Czech Republic to EU. After the year 2008 may be seen a slowdown in GDP growth trend both in the Czech Republic and in Finland owing to economic crisis. To conclusion, generally, in both countries the GDP has growing tendency.

Moreover, the EKC model is constructed per capita, therefore, it is necessary to know the population size for given period and country. The Appendix B or Figure 8 show data on the size of population in the Czech Republic and Finland. It may be observed that the Czech Republic population is twice as large as the population of Finland. Therefore, this consequence may also influence the EKC mode outcomes.

Figure 8: GDP and Population in the Czech Republic and Finland (1990-2014)



Source: Author; The OECD statistic data were used.

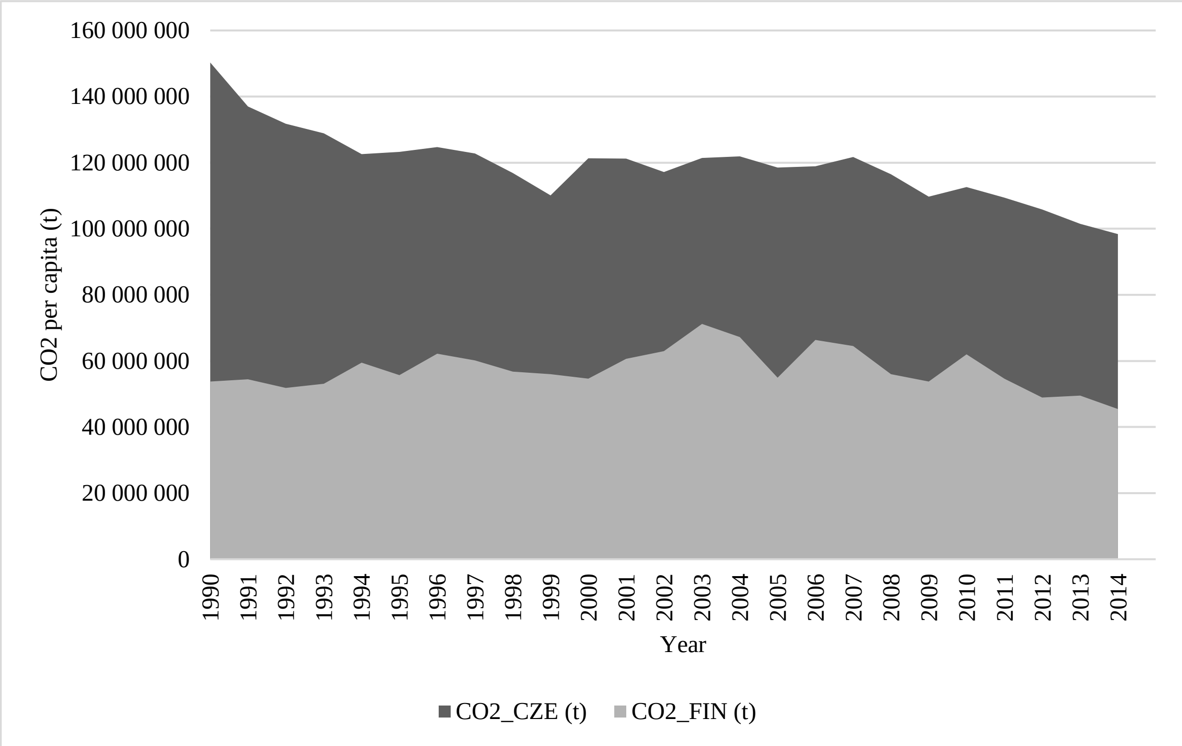
3.2.2 CO2 emissions

Carbon dioxide is known to be one of the most important anthropogenic greenhouse gas that leads to such consequences as a global warming. Small amount of this polluter exists naturally in the atmosphere, but it was found that use of fossil fuels led to an increase of concentration this polluter in the atmosphere compared to preindustrial times. (McCormick, J., 2001, p.183) Emissions come from burning of fossil fuels, industrial and agricultural activities. Moreover, emissions are directly related to the use of energy, which is an essential factor in the world economy, both for production and consumption.

Is has been already reported by other studies (Arrow et al. 1995, Cole et al. 1997, Andreoni 2012) that carbon dioxide emission is not local pollutant, therefore for its reduction higher reduction costs and long-term politics need to be used. Thus, non- demonstration of EKC may be more expected for global pollutants than for local pollutants.

The following Figure 9 shows amount of CO2 emissions between years 1990-2014 in Finland and in the Czech Republic. It may be seen that Finland has the half amount of CO2 emissions concentration than the Czech Republic. It may be caused by many external effects that influence these outcomes. More interesting find is that relatively decreasing trend for CO2 emissions may be observed in the Czech Republic since 1990 unlike Finland's trend of the amount of CO2 emissions that is relatively stable since the year 1990.

Figure 9: CO2 emissions in the Czech Republic and Finland (1990-2014)



Source: Author; The OECD statistic data were used.

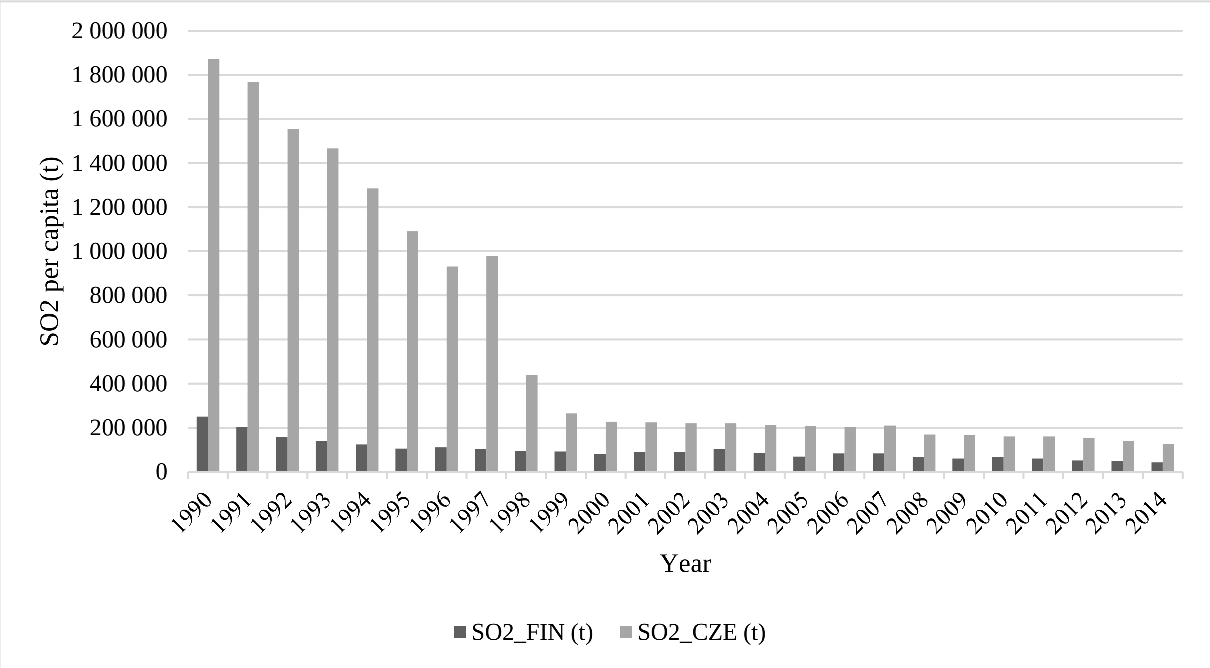
3.2.3 SO2 emissions

The pollutant emerges by reaction with oxygen when the sulphur, which is presents in fossil fuels, releases. (McCormick, J., 2001, p.182, 210) Sulphur dioxide forms sulphate aerosols that have an impact on human health, ecosystems, agriculture, or global and mostly on regional climate. These emissions are produced by incineration of fossil fuels and the sulphur contents in raw materials.

Sulphur dioxide is mainly emitted by power and heat stations and other industries using fossil fuels, oil refineries, or by transport industries. Power stations account more than half of SO2 emissions in the EU and the worst pollution coming mainly from them.

After the year 1990, when the Czech economy was transformed, the amount of SO2 started to decrease. As a main cause of the pollution reduction was a general decline in industrial production and other economic activities that was caused by desirable damping or removal of unproductive energy and raw materials between years 1990-1992. Moreover, since 1992 other effects leading to SO2 emissions reduction have become, for example, a progressive transformation of the national economy, high spending on environmental protection in the public and private sector, the implementation of state environmental policy and the active approach of municipalities and industries. In spite of SO2 emission in the air were significantly reduced until the year 1997 compared to 1990 (see Figure 10), the Ministry of Environment reported that the current concentration of SO2 emission was still twice as large as in the other OECD countries in 1997. Therefore, the Ministry has agreed to continue with measures leading to another emission reduction.

Figure 10: SO2 emissions in the Czech Republic and Finland (1990-2014)



Source: Author; The OECD statistic data were used.

Total spending on environmental protection were relatively higher than in the most European countries and economic transition countries. In 1996 the environmental expenditures as a percentage of GDP were above the 1% of GDP. Total expenditures in period 1992-1997 ranged between 2-2,5 % of GDP.

The air protection expenditures were affected by two different technical measures. The first measure involves large and medium-sized polluters who had to implement all technical measures to achieve the new emission limits since the year 1998. Most of these investments were mainly paid by operators of these energy facilities. For small sources of pollution, the measures were paid mainly from central sources. The second and the most common measure was the transition from solid fuels to gas as the main source for heat generation. (Newsletter of the Ministry of the Environment, ©2017)

3.3 Analysis results

In the following Table 4 shows Ordinary Least Squares (OLS) regression analysis results. Where the initial quadratic regression model [4] and alternative linear model [5] were tested. In case of quadratic dependence conformation (EKC or U-shape dependence), the EKC turning point or the local minimum was calculated for the given indicator according to the equation [6].

The following results **R2** show a proportion of total variability of dependent variable (CO_2 or SO_2 per capita) that regression analysis has been able to explain it. For example, the regression analysis for CO_2 pollutants in Finland has been confirmed for both models (linear and quadratic), nevertheless the R^2 value for quadratic model was higher, therefore, the model was used for better expressing the relationship between variables. **Durbin-Watson's autocorrelation statistics** express a degree of similarity of a time series over the time intervals. Which means that if one variable changes, consequently the second variable changes as well. The D-W statistic is always between 0 and 4. Values approaching to 0 indicate positive autocorrelation between variables or direct relationship between variables that may be also observed from following OLS regression results (see Table 4). **The Shapiro-Wilk's residual normality test** indicates a normal distribution of a given data set. For all data the normality tests have been rejected, thus, the following hypothesis were tested by non-parametric tests.

Table 4: Ordinary Least Squares (OLS) regression results

Index	Absolute coefficient	Linear coefficient	Quadratic coefficient	R2	F	D-W[1]	S-W[2]
CO2_CZE	13,2420*** (7,355)	-0,0344 (-0,1863)	-0,0022 (-0,5181)	0,6370	19,305***	0,5891	Rejected
	14,1462*** (32,479)	-0,1296*** (-6,293)		0,6326	39,602***	0,5810	Rejected
CO2_FIN	1,2992 (0,469)	0,7758*** (3,836)	-0,0139*** (-4,065)	0,4805	10,175***	1,526	Rejected
	12,2383*** (14,592)	-0,0418 (-1,511)		0,0903	2,284	0,8577	Rejected
SO2_CZE	0,5318***	-0,0431***	0,0009***	0,8335	55,064***	0,4335	Rejected

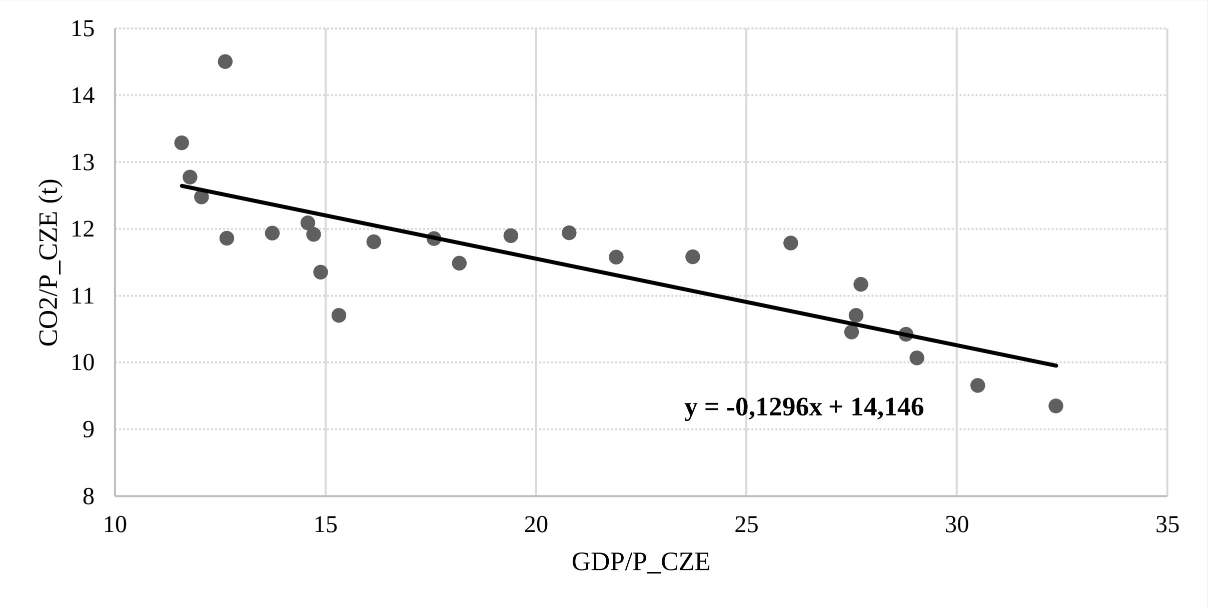
	(8,557)	(-6,749)	(5,794)				
	0,1827***	-0,0063***		0,5793	31,668***	0,1479	Rejected
	(7,691)	(-5,6277)					
SO2_FIN	0,0787***	-0,0035**	0,00004**	0,6797	23,345***	0,4082	Rejected
	(4,589)	(-2,754)	(2,077)				
	0,0441***	-0,0009***		0,6168	37,032***	0,3403	Rejected
	(10,258)	(-6,085)					

*p<0,1; ** p<0,05; *** p<0,01 (t-statistics in brackets)
1) Durbin-Watson's autocorrelation statistics
2) Shapiro-Wilk's residual normality test (p-value)
Source: Author. The OECD statistic data were used.

3.3.1 CO2 and EKC

In the case of the relationship between CO2 emissions per capita and GDP per capita between years 1990-2014, the regression analysis did not confirm EKC hypothesis in the Czech Republic. Instead, the linear regression model confirmed indirect dependence between the EKC model variables. In comparison with other EKC studies on CO2 (see Table 2), the result is in a contradiction whit these studies in which the indirect linear dependence was observed very sporadically.

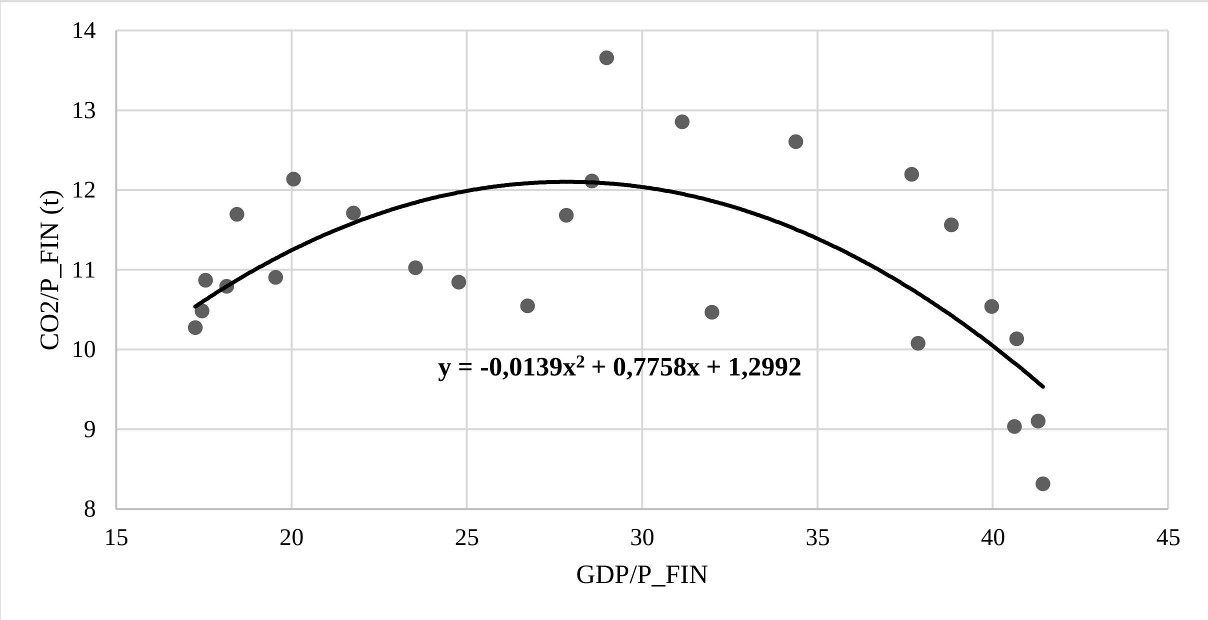
Figure 11: EKC and CO2 in the Czech Republic



Source: Author.

On the contrary, in the case of the EKC model testing for Finland, the regression analysis confirmed the dependency between CO2 per capita and GDP per capita between years 1990-2014. The shape of dependence may also be observed from the graph below (see Figure 12). Depending on the relation [6] the EKC model turning point is observed 27 851 UDS per capita. This value Finland reached between years 2001-2002 (see Table 5).

Figure 12: EKC and CO2 in Finland



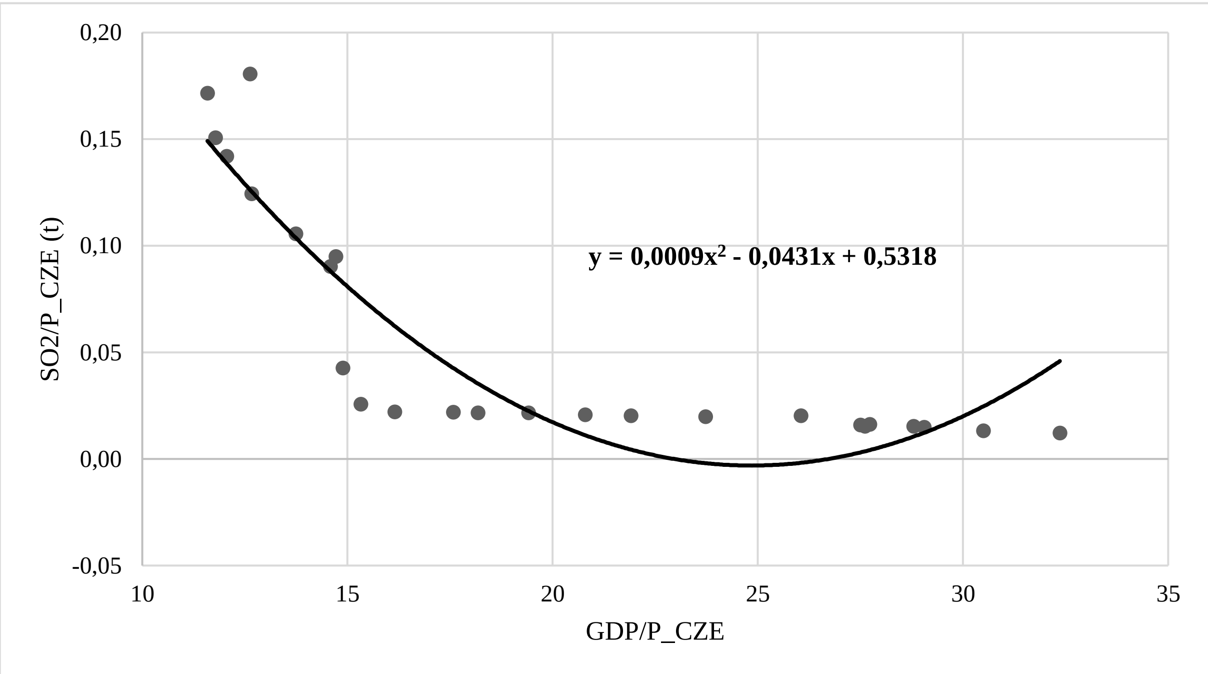
Source: Author.

For both above-mentioned models, the residual normality was rejected. The D-W statistics indicates positive autocorrelation of residues for both analyses.

3.3.2 SO2 and EKC

The dependence between SO2 per capita and GDP per capita in period 1990-2014 for the Czech Republic may be characterized by the quadratic regression model of U shape dependence (see Figure 13). Alternatively, the linear regression model of indirect dependence could be also applied to this relationship, however, the quadratic model is characterized by a higher R2 statistic. Thus, the local minimum is calculated by equation [6]. The amount is found to be 24 841 USD per capita that corresponds approximately to period 2006-2007 (see Table 5). Both CO2 and SO2 emissions conclusions differ from the finds of other EKC studies (see Table 2 and Table 3). The U-shape curve was not found in any research mentioned in Table 3. In addition, this U shape curve occurred only rarely in other studies.

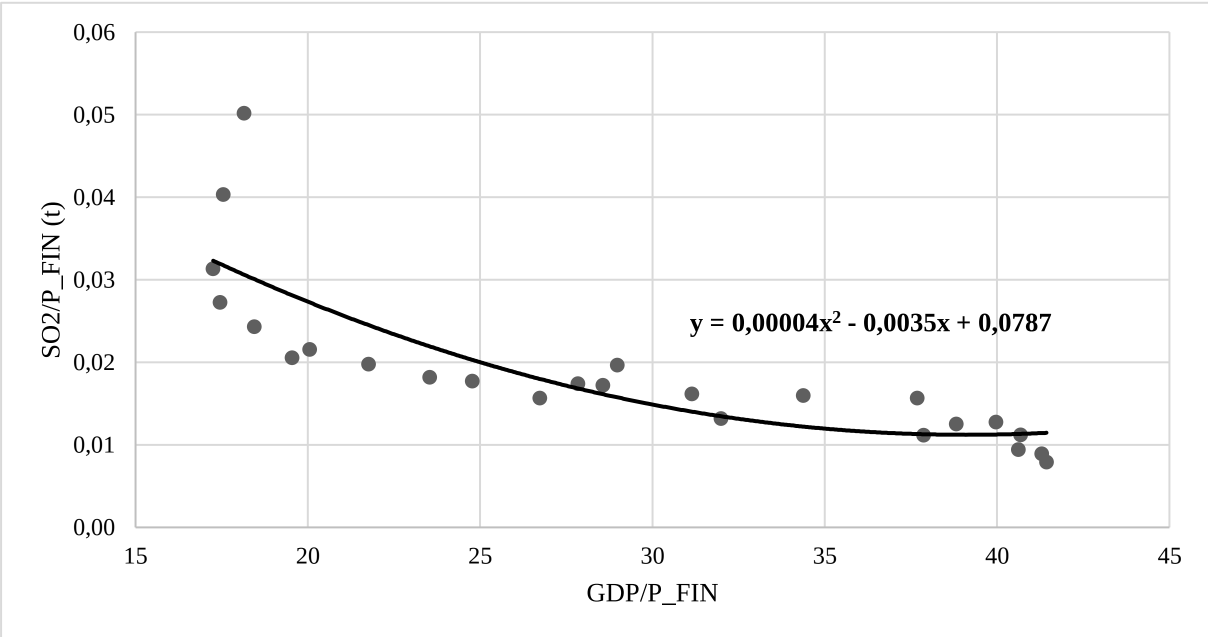
Figure 13: EKC and SO2 in the Czech Republic



Source: Author.

A similar result of the regression analysis was found for Finland SO2 emissions. The analysis confirmed the U-shape curve as well as indirect linear dependence. However, R2 for quadratic regression analysis was higher, thus, U shape curve was chosen for better expressing the relationship between SO2 emissions per capita and GDP per capita. The local minimum was found at 39 117 USD per capita that approximately corresponds to the level between years 2007-2008 (see Table 5).

Figure 14: EKC and SO2 in Finland



Source: Author.

In the year 2010 was issued J. Kunna's study which analyzed the EKC model in Finland between years 19950-2001. The study is based on Stern's and Hoffrén's approaches and finds on SO2 emission during this period. Their analysis confirmed inverted U-shape curve corresponding to EKC. The turning points were found for years 1973 and 1980, but this difference was caused by used data by Stern, thus, the turning point is approximately around the year 1980. The main reason for SO2 emissions decline Kunnas explains as follows: *"the total emissions of sulphur dioxide started to decline after 1973, shortly after the publication of* *the Swedish report, of the damage caused to soils and lakes because of sulphur in air and precipitation, at the 1972 UN Conference on the Human Environment in Stockholm."* (Kunnas, 2010, p. 1588)

Hence, it may be said that if the data needed for the EKC model between 1950-2014 were available in OECD statistics and used in this study, it may be assumed on the basis above-mentioned study that N-shaped EKC would be achieved also in this thesis.

The following Table 5 shows and summarizes results obtained by regression analyses in this thesis.

Table 5: Regression analysis results

Index	Time horizon	Model	Turning point (GDP/P)
CO2_CZE	1990-2014	↘	-
CO2_FIN	1990-2014	∩	Estimating turning point is **27 851 USD** (It corresponds approximately to the years 2001-2002)
SO2_CZE	1990-2014	∪ (eventually ↘)	Estimating local minimum is **24 841 USD** (It corresponds approximately to the years 2006-2007)
SO2_FIN	1990-2014	∪ (eventually ↘)	Estimating local minimum is **39 117 USD** (It corresponds approximately to the years 2007-2008)

Source: Author.

3.4 Discussion

The following chapter discusses limitations of the EKC regression analysis in this thesis that could have affected results and conclusions based on these results. Individual limitation issues will be presented and also possible solutions how to minimize these limitations and their effects on the EKC model. The second part deals with the empirical analysis of the external effects, which have been already introduced in the first chapter. On the basis of regression analysis results on CO2, and SO2 emissions in the Czech Republic and Finland these effects will be discussed and subsequently disproved or confirmed their effects for the individual country.

3.4.1 The EKC model limitations

The EKC model involves only one form of human intervention in the environment

Not only emitting substances into nature by human activities but also by removing substances from nature and interference in nature of substances lead to environmental degradation. These activities may cause permanent impacts or partially renewable impacts on the quality of the environment. However, the EKC hypothesis is mostly focused only on one type of human activity.

The EKC model mostly considers emitting substances in nature, there are also studies focused on removing substances from nature. However, this thesis is only focused on one factor in the regression model, therefore, based on the results from the chapter 3.4, positive effects leading to environmental remediation cannot be confirmed or rejected. Accordingly, only the increase of CO2 emissions in relation to GDP per capita growth in Finland and in the Czech Republic may be confirmed. Owing to that, some improvements in air quality and climate could also occur, but it could not be necessarily true.

The EKC model is not comprehensive

It is mean that model is focused only on one effect and not considers multiple levels of effects that may lead to air and climate improvements or their damages. In order to achieve a remedy of human actions, in the case of air quality and climate, the complex set of measures have to be taken into account. It should be also considered, how one effect may influence the other one and how these interactions will have an impact on the monitored indicator.

Secondly, there is a question of responsibilities. Who is responsible for air and climate quality and how these responsibilities may be implemented and who should be affected by? Therefore, for analysis of effects causing air pollution and climate degradation, multiple effects and their interactions should be considered. In the case of responsibility for air quality and climate, the government or central level regulator should be considered and set up limits to avoid prevent future degradation of a monitored component. How the government can intervene in environmental problems to avoid future environmental degradation and protect it for future generations through regulations and the most appropriate tools for different types of environmental damage problems it is shown in Figure 7. However, government's spending, subsidies, and interventions may also affect the level of pollution in a negative way (see Figure 7).

As an indicator of human wealth in the EKC model GDP is used. However, GDP not measure welfare, but only the country's wealth growth over the certain time period. Moreover, GDP does not include the benefit of the free time or benefit from certain environmental quality. On the contrary, the welfare and prosperity cannot be measured perfectly, therefore GDP can be regarded as the most suitable indicator for this data.

In conclusion, in this thesis has been found a reduction in a concentration of CO_2 pollutants in relation to the increase in GDP per capita, thus, it may be assumed that under unchanged conditions this effect could lead to the improvement of the air and climate quality. However, the decrease in CO_2 emissions could be followed by an increase of other pollutants influencing both the air and climate quality, consequently, the above-mentioned assumption would not be true.

Insufficient data

The last but not least, another problem with the EKC model is insufficient data. Therefore, for analysis of effects causing air pollution and climate degradation, multiple effects and their interactions should be considered. Data are usually very hard to reach, and their empirical validity cannot be established easily. Moreover, due to internationally fragmented data, different rules for data collection and calculation may be expected. Hence, these data cannot be used in the same model or compared to each other.

For the purpose of this thesis were used data between years 1990-2014 provided by OECD data databases. The time period was limited from the year 1990 because information about SO2 and CO2 emissions have not been collected. Therefore, the EKC model may be limited by a short time period of data sources that cannot provide a comprehensive view on the issue and may also lead to misleading conclusions as may be seen in the case of regression analysis on SO2 emissions in Finland. For this time period, the analysis said that EKC curve has N-shape curve between years 1990-2014, but the previous study issued by Kunnas found the inverted U-shape curve for the period between 1950-2001. Therefore, it may be seen that different range of data may provide different conclusions.

3.4.2 Discussion of external effects impact on the regression model

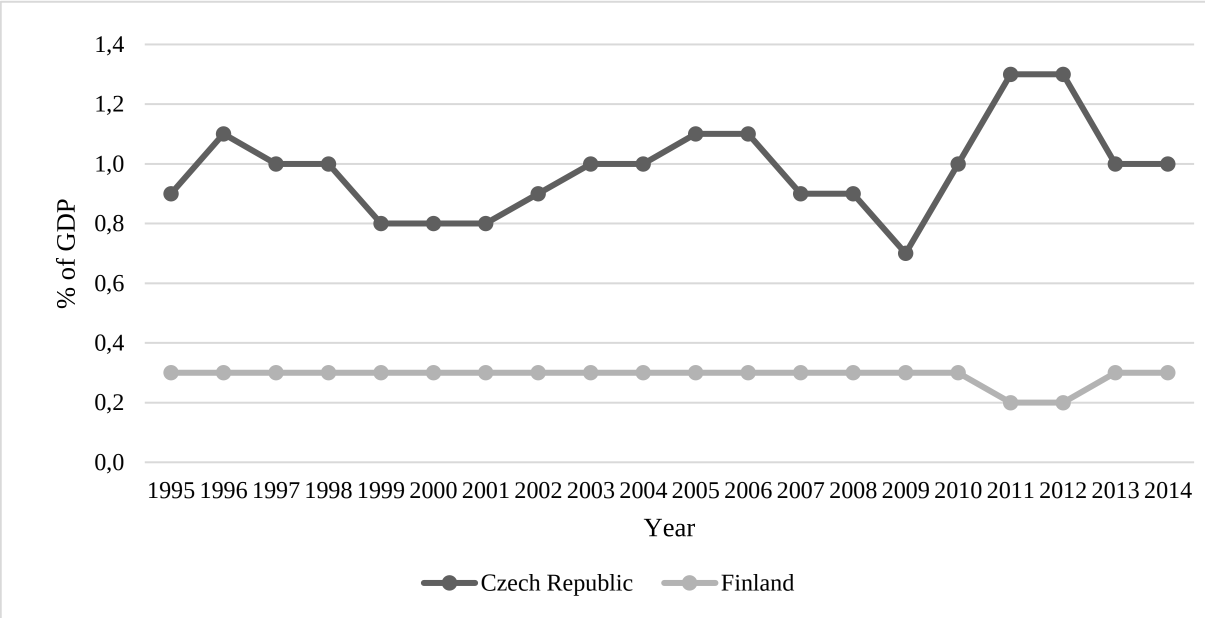
Government expenditures

After people reach a certain level of income and their well-being is satisfied, they start to perceive other needs that would contribute to their living condition satisfaction. Theory says that people start to pay the attention to environmental conditions and start to create a pressure on environmental policy and regulations.

Moreover, in this stage, government operates whit more financial sources than in the early stage of development, therefore the government may not only focus on the economic growth as in the early stage of development and can deal with other issues. The government may support new kind of technologies that are not as environmentally demanding as current technologies. Moreover, environmental policy can start to be more focus on preventive tools as education, research and science in the environmental field.

The Figure 15 shows total general government expenditures as a percentage of GDP between years 1993-2014. While Finland has relatively stable expenditures at 0,3% of GDP, expenditures of the Czech Republic are more volatile. The expenditure fluctuations influenced both the accession to the EU when the Czech Republic gained access to EU funds and the economic crisis which, on the contrary, reduced the amount of environmental expenditure. However, as regression analysis results show, environmental protection expenditures do not have to be as much significant as, for example, the level of environmental taxes or preventive measures. Because, from the long-time period view, the country should be more focused on long-time environment sustainability that preventive tools allow.

Figure 15: Total general government expenditure on the environment (1995-2014)



Source: Author. The OECD statistic data were used.

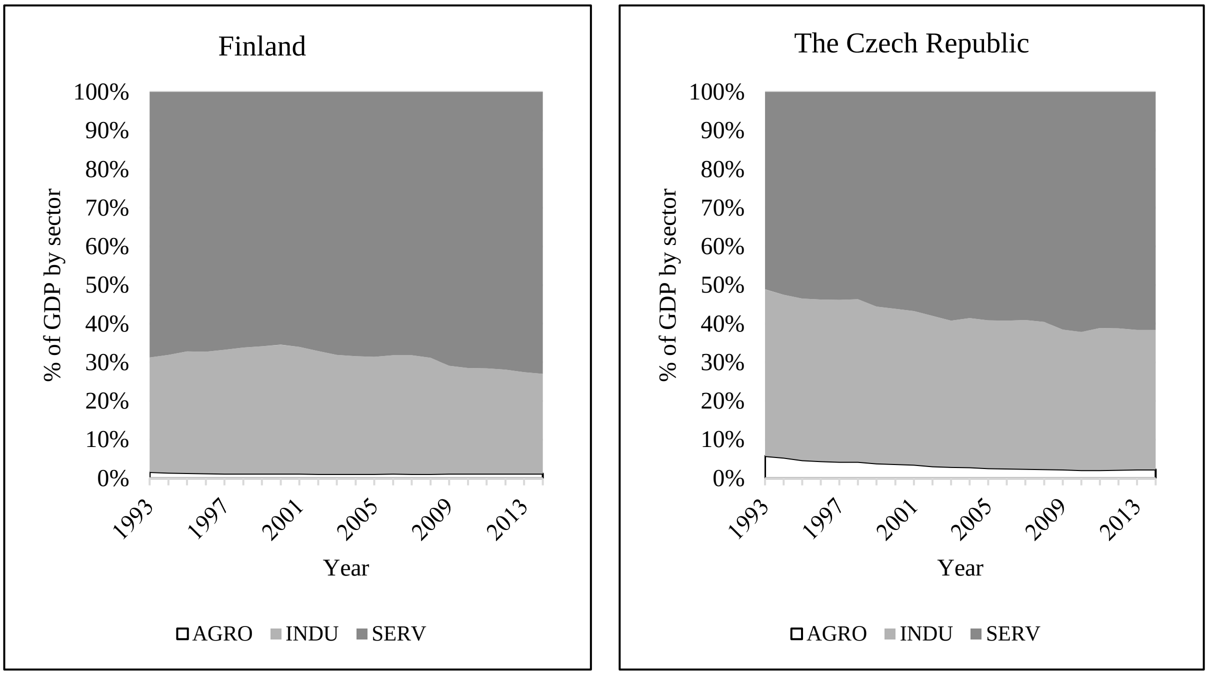
Size of the economy

For the purpose of EKC hypothesis are defined three sectors in the economy: agriculture, industry, and services. The EKC theory says that each country has to pass different stages during economy development, which EKC theory define and connect them with one of the three above mentioned sectors (see Figure 2). The ratio of individual sectors representation in the economy affects both the level of the country's mature as well as amount of environmental pollution.

On the bases of EKC analysis results, the theory distinguishes the maturity of the economy according to phase (see Figure 2) which the economy is situated in. As it has been already mentioned, developed countries are characterized by a major rate of services on GDP. Therefore, it may be said that if the country is already in a phase beyond the turning point, the environmental pollution proportion or occurrence of certain pollutants is lower than in the countries in early stage of development or before reaching the turning point. This statement may be also seen in this research.

According to the quadratic regression analysis results for CO_2 and SO_2 pollutants in the Czech Republic and in Finland, the EKC hypothesis was confirmed for CO_2 pollutant in Finland and for SO_2 pollutant in both countries. From the regression analysis of CO_2 pollutant model in Finland (see Figure 12) may be seen the inverted-U shape curve corresponding to the shape of EKC. Therefore, the EKC relationship between CO_2 emissions and GDP per capita may be confirmed. In the case CO_2 pollutant, Finland has already passed the turning point at 27 851 USD. In the year 2014, the amount of CO_2 pollution per capita was found to be in the down-sloping part of the EKC model. Moreover, as theory says, according to the EKC model, Finland has been found to be in the third stage of economic development, thus, the highest share of services in the economy may be expected. This empiric hypothesis has been confirmed on the base of services ratio on GDP as shows Figure 16.

Figure 16: The share of individual sectors as a percentage of GDP (CZE and FIN 1993-2014)



Source: Author. The OECD data were used.

Structural changes of the economy

Economy structural change is influenced by country’s economic development; thus, this topic also relates to the previously discussed issue.

The EKC theory says: *Along with the economic growth, the economy tends to change its structure.*

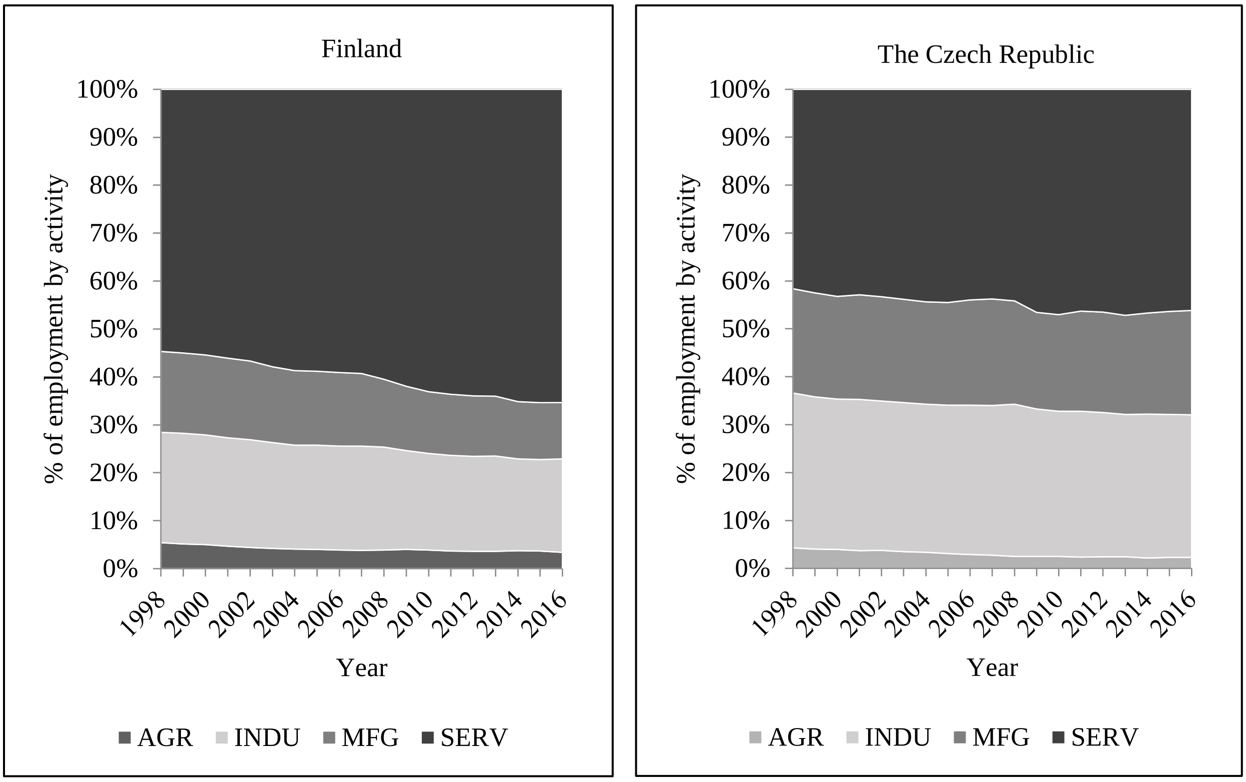
It means that at the early stage of economic development, the major percentage of GDP is represented by agriculture. Along with the income growth, the economy moves to the 'industry stage' (see Figure 2). Increasing income affects society preferences, technologies, process etc., hence, the last stage of economic development is associated with highly sophisticated technologies and environmental regulations, the stable share of industry and a higher percentage of services that cause less environmental degradation than heavy industry sector. Consequently, the country's environment also goes through certain development, owing to the intensity of individual polluters that influence individual environmental areas in each development phase, which is characterized by a majority share of the individual sector on GDP.

In the early stage of economic development, the agriculture sector is not as demanding for resources and impact of individual pollutants on the air quality is not as considerable as in the industrial development phase. Although for other environmental segments (water, foresting, fishing etc.) this impact may differ. Industrial time of economy development is characterized by higher proportion of environmental pollutants, especially on the air quality. In this period, the environmental quality is less advanced, because all priorities are focused on economy growth and environment is not as important for the country prosperity in this stage of development. On the contrary, quality environmental condition become to be important in the last stage of economy development. Increasing country wealth change people’s priorities in the environmental area, thus, for example, R&D, more sophisticated technologies and new environmental regulations become country priorities. Consequently, the decrease in emissions should be recorded than in previous stages of development.

In our case, in both countries, the major percentage of GDP is represented by sector of services (see Figure 16). Moreover, still increasing the percentage of employment in the service sector may be also observed (see Figure 17). Therefore, it may be expected according to the EKC theory that the countries are already in the last stage of development (in the post-industrial economy), hence, the amount of emitted air emissions should not be as huge as in the previous two development stages.

For CO_2 emissions in Finland, the quadratic regression analysis confirmed the EKC model (see Figure 12). Finland has already reached the turning point and with increasing GDP per capita may be noticed a decrease of CO_2 emissions. For SO_2 emissions the results differ from the CO_2 pollutant. For both countries, the U-shape curve may be seen (see Figure 13 and 14), it is mean that both have already reached the local minimum (see Table 5) and the SO_2 emission started to grow again with increasing GDP per capita. Rather than U-shape curve or inverted-U shape the EKC model the N-shape curve may be assumed for this pollutant. Nevertheless, due to an insufficient data set, this assumption cannot be confirmed by real data. The explanation of the background of the N-shape curve may be due to, for example, changed society preferences (Beck, 2015) or, for instance, mitigation of environmental limits by the government, etc.

Figure 17: Employment by activity (1998-2016)



Source: Author. The OECD data were used.

Liberalization of economies

Grossman and Krueger (1995) dealt with the effect of trade barriers reduction between Mexico, the USA, and Canada.

The economic theory says: *"When the country enters the international market, total benefits are higher than loses for a particular country."* (Mankiw, 2000)

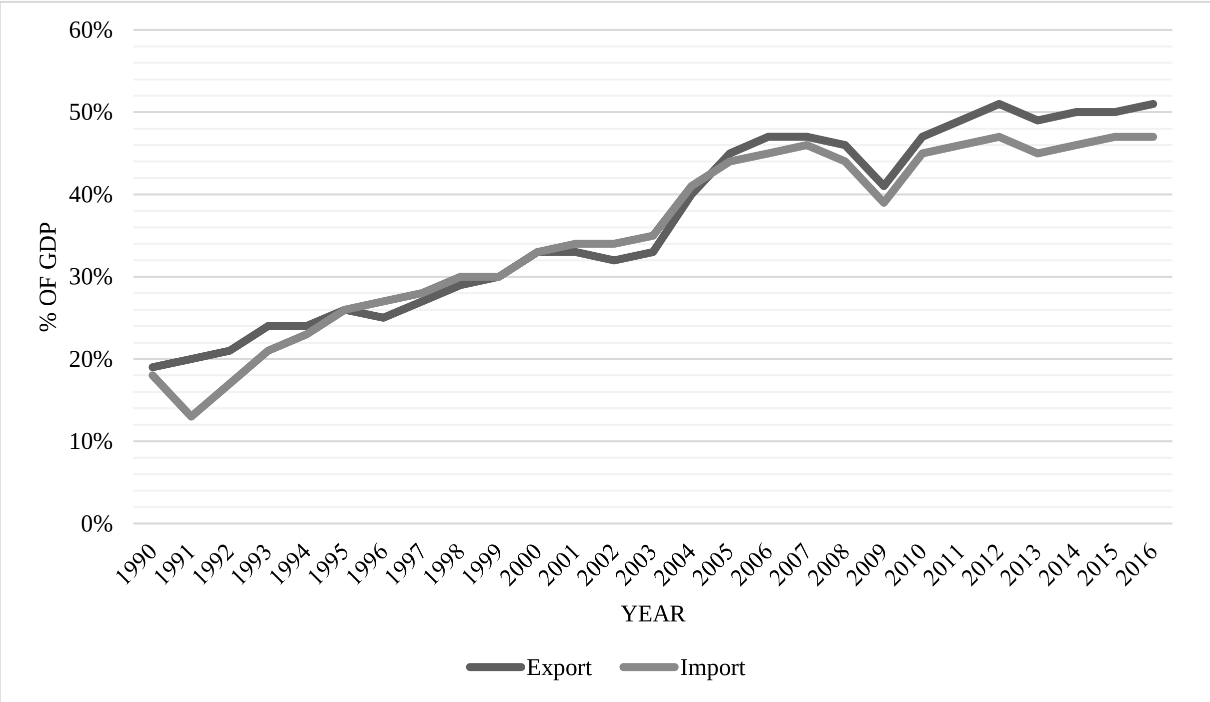
The idea of trade barriers reduction was mostly criticized by environmental organizations, due to negative environmental consequences relate to border reduction (see chapter 1.1). Nevertheless, on the other hand, the country may gain an access to international trade and to international capital flows. Accordingly, the country will be able to invest in sophisticated technologies and other techniques and processes that allows protecting the environment. In addition, if a country has a comparative advantage in activities that are not capital-intensive or resource-intensive to produce large amounts of pollution, after a certain time of period, the country can start to import these products from other countries and thereby limit and reduce environmental pollution.

However, this issue is more related to GDP growth and consequences for particular pollutants. The access to the international market is the source of capital that supports country economy. Consequently, the process of economic development starts, and the prosperity of the country begins to grow.

After the year 1989, the economy in the Czech Republic was transformed and as a consequence, the country gained the access to international market and to many products and services that also contributed to the country's economic growth (see Figure 8). Since that time the number of exports and imports (as % of GDP) have increasing trend (see Figure 18).

In addition, the development of environmental and other regulations as well as an access to various international institutions focusing on the quality of the environment was associated with this period. In accordance with trade openness, the still decreasing trend of SO2 and CO2 emissions in the Czech Republic may be also observed.

Figure 18: Exports and Imports as % of GDP (CZE 1990-2016)



Source: Author. The OECD data were used.

Environmental regulations

As the last discussed external effect is environmental regulations. Due to characteristic features, the environment and the air are considered to be a public good. Consequently, the government should be responsible for its condition and quality.

The government can manage consequences of negative externalities through a variety of environmental tools. For example, the first economic tool in the form of carbon taxes was introduced in Finland in 1990. The carbon tax meant another source of revenue into the public budget and also the tool how to decrease a level of CO2 emission in the air. The second instrument used by government are administrative tools, for example, emission limits. These limits only set the amount of pollution and punishments for non-compliance with the limit. Thus, their motivation effect is not as significant as, for instance, for taxes. The last used tool is EU ETS that began to be used by EU in 2005 (see chapter 2.2).

The Figure 12 shows inverted U-shape of EKC in Finland for CO2 emissions and Figure 11 shows monotonic decreasing relationship for CO2 emissions in the Czech Republic.

In case of Finish EKC, in the background of the regression analysis may be environmental regulations. However, initially, it should be noted that Finland, unlike the Czech Republic, paid attention to environmental issues already before the year 1990. This attention was allowed due to its stable system and market-oriented economy.

Due to achieving the Kyoto protocol commitment form 1997 and achieving the 1990 year's level of GHG emissions till the period 2008-12, the decrease of CO2 emissions is observed from the year 2005. In 2011 Finland has started to support EU's commitment to decrease emissions about 20% below the 1990 year's level. Moreover, in 2010 was adopted a 'National renewable energy action plan' that set a national target to use 38% of energy from renewable sources by 2020 (Finland has already achieved this target, in 2016 approximately 45% of electricity and 57% of industrial heat were produced by use of renewable sources). (Statistics Finland, ©2017)

On the other hand, in the case of the Czech Republic (see Figure 11) the monotonic decreasing relationship between variables may be observed. The transformation of the economy in the early 1990s and higher financial attention to the environmental issues in that time caused a decrease of emission with higher probability than environmental regulations. In addition, after the Czech Republic joined the EU in the year 2004, more environmental regulations with stricter emission limits began to be obligatory or recommended for Czech environmental policy. Therefore, it may be said that the Czech Republic has not had the opportunity to rise and decrease again its emission in the monitored period 1990-2014, thus, EKC could not have been proved.

In the case of SO2 emission, the U-shaped curve was found for both countries. In Finland, the local minimum was found between years 2007-2008. Increasing amount of SO2 emissions may be a consequence exemptions peat from tax between years 2005-2010. Consequently, higher use of peat as a source of electricity could have been also one of the consequences of emission increase. However, peat is considered as a natural source for energy production, its produced emissions with the almost same amount of pollution as coal does.

In the Czech Republic was observed decreasing trend of SO2 in period 1990-99 that may be a reaction to economic transformation and higher attention on the environmental situation by the government. Furthermore, a regular monitoring of the environmental situation, and joining international organizations also helped to reduce air pollution. Owing to preparation for joining EU, the Czech Republic also became part of Phare program in 1990 that has financially supported environmental projects in the Czech Republic. Moreover, in the same year, the Czech Republic accepted program considering the future path of the environment and its targets. At the beginning of the 21st century, the rapid decline in SO2 emission slowed down, and the amount of pollution began to decline even more moderately. Nowadays, the SO2 pollution reduction may be still observed. In conclusion, despite SO2 pollution was found to have the

U-shaped curve, which could indicate increasing amount of SO2 emission with increasing country's wealth, nevertheless, this conclusion may not be necessarily true. Due to an insufficient data set, which is provided only until the year 2014, the above-mentioned claim may not be even true due to continued emission reduction.

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CONCLUSION

In this Master's Thesis, I have dealt with the Environmental Kuznets curve. ***The main objective was to prove or disprove the theory of Environmental Kuznets Curve for individually selected pollutants (CO2, etc.) through mathematical and statistical methods and data of the Czech Republic and Finland. Depending on the different levels of environmental pollution in the Czech Republic and Finland case studies will be compared. One of the partial objectives will be an evaluation of factors (internal and external) that could influence the waveform of Kuznets curve.*** Since the air is considered as a public good, therefore for its protection or improvement the international cooperation between countries is needed, thus, the attention was mainly paid to the external effect of environmental regulations.

Environmental Kuznets curve hypothesis says: *"Pollution appears to rise with GDP at low levels of income, but eventually to reach a peak, and then to fall with GDP at higher levels of income. Therefore, the relationship between environmental degradation and income is represented as an inverted U-shape of the Environmental Kuznets Curve."* (Grossman & Krueger, 1995) The EKC model is represented by two variables: a particular pollutant occurring in the air or in the environment, and GDP as the most appropriate variable expressing country's wealth. As a consequences of country's wealth growth, the various responses of individual subjects, which are reflected on GDP growth's intensity or on the amount of environmental pollution, may be observed.

Market openness cause capital and technology flows that are used for development of new sophisticated technologies and the production methods. Along with growing income, the society reach its state of well-being and its interest begins to be more focused on previously luxury goods - the environmental conditions in their living area. Also, the government perceives country from a wider perspective now and spreads its attention, for example, to the environment quality condition. Moreover, owing to higher quality of living, the society starts to change its preferences. It is mean that higher demand may be observed in services sector, which may gradually lead to economy structural changes.

Environmental regulations have a task to mitigate the effects of environmental pollution and to find ways how to moderate the pollution or prevent it. In addition, the environmental policy would need to find an adequate tool how to measure impacts of individual regulations on specific subjects and their reactions on them.

In order to the adequacy of this tool, all causes of environmental impacts should be also included. It means, not only impacts of emitted pollutants on the environment but also impacts of natural sources that are extracted from the nature and which help to moderate or, on the contrary, amplify the consequences on the environmental quality (for example deforestation, extraction, etc.). Therefore, a certain modification of EKC, respectively inclusion of all significant effects into the EKC equation, could become a specific environmental tool reflecting changes and environment-related responses.

Based on the Master's Thesis results, the used EKC equation should not be adopted as the environmental policy instrument. The curve does not reflect a coherent form of reactions, but only the reaction of one particular pollutant. Therefore, on basis of the EKC results, it is not possible to say whether the environment has improved/worsened, because the only one element was monitored. However, it could be said that the air's pollutants decreased with increasing income, thus, an improvement in the air conditions may be expected. Nevertheless, this claim may not be true as well, because the emission of another pollutant which is not the study's subject could increase or new pollutants could occur. Therefore, the main air's polluters should be monitored at the same time through complex EKC model that would be able to show sufficient outcomes.

In the case study, the existence of EKC has been proved only for CO_2 pollutant in Finland. In the Czech Republic the regression analysis has found the monotonic decreasing relationship between variables. In the case of SO_2 pollutants, neither for the Czech Republic nor for Finland, EKC has been proven. For both countries the relationship between variables has been found as the U-shape curve. The above-mentioned results show reaction and some relationship between EKC's variables, which react to each other. The monotonic decreasing relationship between variables may indicate the period already behind the turning point. It means that economy is developed and the country (also countries that may affected the emission amount) spends its resources and targeting its environmental policies successfully on CO2 pollutants reduction. On the other hand, the country could have also decided to import the goods whose production causes considerable pollution. However, in this case the main cause are environmental regulations rather than import of heavy pollution products.

The U-shaped curve for SO2 pollution could have reached also to the inverted U-shaped curve in the past. It means that due to insufficient data set the regression analysis has been able to show only already declining part of the curve, the local minimum, and again the rising part of the curve. Nevertheless, based on previously conducted studies, with a larger amount of historical data, the U-shaped curve could have been also proved for Finland. In the case of SO2 pollutants in the Czech Republic, this prediction may not be necessarily true, because information about the amount of environmental emissions began to be collected since the year 1990.

I can conclude that on the basis of all my results and measurements, the statement in the research question has been proven and the EKC hypothesis has shown to be proven only for CO2 emissions in Finland. Insomuch, the regression analysis has been found to may be influenced by various limitations, therefore only certain part of EKC may be displayed, thus, the EKC hypothesis validity for some remaining analyzes can be also partially confirmed. To continue, since some of the internal and external factors have empirically confirmed to be also associated with the EKC hypothesis, the statement of the partial objective has been proven as well. Last but not least, since Finland is considered to be one of the most environmentally-based European countries, therefore, the secondary outcomes of the EKC analysis and empirical analysis of environmental regulations showing slowly approaching

trend of the Czech environmental development to Finnish environmental trend is considered as the second most valuable Master Thesis's result.

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EU	The European Union
EKC	The Environmental Kuznets Curve
CO2	Carbon dioxide
SO2	Sulphur dioxide
GHG	Greenhouse gas
CZE	The Czech Republic
FIN	Finland
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares regression
EU ETS	The EU Emission Trading System
GDP	Gross domestic product
NAFTA	North American Free Trade Agreement
R&D	Research and Development
PHH	Pollution Haven Hypothesis
TP	Turning point
HS	Human subsystem

ES	Environmental subsystem

APENDICES

Appendix A: The OEDC statistics on GDP

Year	GDP_CZE (thnd USD)	GDP_FIN (thnd USD)
1990	130 810 315	90 495 199
1991	119 465 092	87 976 922
1992	121 569 423	86 990 819
1993	124 538 925	88 406 414
1994	130 889 609	93 844 493
1995	141 932 557	99 832 292
1996	150 439 327	102 792 201
1997	151 680 334	111 860 586
1998	153 296 010	121 285 562
1999	157 590 965	127 941 842
2000	165 910 036	138 372 033
2001	179 758 970	144 404 753
2002	185 474 090	148 566 434
2003	198 017 732	151 089 704
2004	212 241 011	162 805 999
2005	224 201 381	167 840 451
2006	243 585 311	181 069 067
2007	268 950 096	199 323 187
2008	289 157 149	212 373 369
2009	288 540 120	202 176 147

2010	290 360 275	208 164 037
2011	302 260 236	219 214 027
2012	305 309 371	219 916 339
2013	320 535 097	224 594 224
2014	340 575 339	226 716 951

Appendix B: The OEDC statistics on Population

Year	**P_CZE**	**P_FIN**
1990	10 362 740	4 986 000
1991	10 308 680	5 014 000
1992	10 317 810	5 042 000
1993	10 330 610	5 066 000
1994	10 336 160	5 088 000
1995	10 330 760	5 108 000
1996	10 315 350	5 125 000
1997	10 303 640	5 140 000
1998	10 294 940	5 153 000
1999	10 282 780	5 165 000
2000	10 272 500	5 176 000
2001	10 224 190	5 188 000
2002	10 200 770	5 201 000
2003	10 201 650	5 213 000
2004	10 206 920	5 228 000
2005	10 234 090	5 246 000

2006	10 266 650	5 267 000
2007	10 322 690	5 289 000
2008	10 429 690	5 313 000
2009	10 491 490	5 339 000
2010	10 517 250	5 363 000
2011	10 496 670	5 388 000
2012	10 509 290	5 414 000
2013	10 510 720	5 439 000
2014	10 524 780	5 472 000

Appendix C: The OEDC statistics on CO2 emissions

Year	CO2_CZE (t)	CO2_FIN (t)
1990	150 300 000	53 800 000
1991	137 000 000	54 500 000
1992	131 800 000	51 800 000
1993	128 900 000	53 100 000
1994	122 600 000	59 500 000
1995	123 300 000	55 700 000
1996	124 700 000	62 200 000
1997	122 800 000	60 200 000
1998	116 900 000	56 800 000
1999	110 100 000	56 000 000
2000	121 300 000	54 600 000

2001	121 200 000	60 600 000
2002	117 200 000	63 000 000
2003	121 400 000	71 200 000
2004	121 900 000	67 200 000
2005	118 500 000	54 900 000
2006	118 900 000	66 400 000
2007	121 700 000	64 500 000
2008	116 500 000	56 000 000
2009	109 700 000	53 800 000
2010	112 600 000	62 000 000
2011	109 400 000	54 600 000
2012	105 800 000	48 900 000
2013	101 500 000	49 500 000
2014	98 400 000	45 500 000

Appendix D: The OEDC statistics on SO2 emissions

Year	SO2_CZE (t)	SO2_FIN (t)
1990	1 870 913	250 118
1991	1 767 486	202 101
1992	1 554 424	157 917
1993	1 466 041	137 966
1994	1 284 796	123 573
1995	1 090 231	104 890

1996	931 112	110 370
1997	977 452	101 566
1998	438 271	93 688
1999	264 352	91 416
2000	227 029	80 995
2001	223 804	90 320
2002	219 635	89 400
2003	219 635	102 446
2004	211 565	84 553
2005	207 711	69 141
2006	203 494	84 043
2007	209 039	82 799
2008	168 880	67 744
2009	165 881	59 515
2010	160 303	67 099
2011	160 434	60 391
2012	155 010	50 953
2013	138 961	48 422
2014	126 772	43 204